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Editor: JOHN M. COULTER

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THE
BOTANICAL GAZETTE

APRIL 1911

ALTERATIONS IN HEREDITY INDUCED BY OVARIAL TREATMENTS

D. T. MACDOUGAL

(WITH PLATES XIV–XVI AND THREE FIGURES)

During the course of an extended series of experimental cultures of the mutants of the oenotheras and of a large number of other evening primroses native to America, the author conceived the idea early in 1905 that agencies of any kind which might affect the processes of the protoplasts concerned directly in the development of the embryo sac and the differentiation of the egg, and which inhibited or altered the reaction velocities of any process, whether catalytic or otherwise, might cause some alteration in the characters transmitted to the progeny arising from fertilizations into which had entered elements affected in this way.

Brief announcements of the progress of the investigation have been made from time to time, as indicated by the appended bibliography, but it has been deemed advisable to present a résumé of the entire subject, which should include a description of the technique and character of the plants employed, together with the results of the culture of the affected species through a number of generations. It may as well be stated in advance that the earlier conclusions, that the sum of hereditary characters in pedigreed lines of plants may be altered by solutions applied to the ovaries in the stage immediately preceding fertilization, are confirmed by the extended work on the matter, and that one of the earliest derivatives secured in this manner has been carried to the fifth generation without showing indications of returning to the parental type.

The original purpose was to test the matter of localization of the supposed alterations by which discontinuous variations occur in hereditary lines, a matter to which attention was directed by the suggestion of DEVRIES that mutations as exemplified by the derivatives of the oenotheras were consequent upon changes in the germ-plasm ensuing previous to the reduction divisions, and, if such localization were established, it was hoped that new mutations might be induced experimentally by controlled conditions or reagents.

As has been pointed out recently, CHARLES DARWIN had attempted to induce alterations in leaves by the injection of reagents which might have acted after the manner of the substances to which galls are due, but this effort was unknown to me, and it may be stated that no results of any kind were secured by him (**6**).

The announcement of the preliminary results to be described here brought out the information that various workers had placed the bases of excised inflorescences and branches in solutions in the effort to cause embryogenic alterations, and also that specialized water cultures had been used, but without result.

The initial tests were so planned as to include the introduction of solutions into the ovary at a time when pollen and egg were in the stage immediately preceding fertilization. Two plants were chosen for the first trial: *Oenothera biennis*, the form known to American botanists as growing wild under that name; and *Raimannia odorata*, native to Patagonia, and now distributed about the world. Pure-bred material of both species, which had been guarded from possible intercrossing since its introduction into the cultures, was available. Thousands of individuals of many generations of both plants had been cultivated, and in no single instance has anything beyond the well known forms of fluctuating variability been shown, except when diseased plants were encountered. Better authenticated material would be difficult to procure, although, as was proven later, the mechanical conditions offered by the reproductive apparatus of these plants were of such character as not to facilitate the treatment.

It was realized very quickly, however, that the use of the

methods might secure some evidence of value in its bearing upon the influence of environic factors upon germ and soma and their inheritance. This aspect of the matter has taken on an increasing importance, and a score of workers are now busily engaged in experimental inquiries by various methods for the purpose of securing evidence on this subject.

An announcement had been made earlier that *O. biennis* was in a state of mutation, but the cultivation of a second generation demonstrated that the changes under observation were due to a fungal infection (1).

The first series of reagents used were selected for the reason that they might withdraw water from the protoplasts or, by permeating the membranes, exercise a stimulative or inhibitive action upon some of the features of cell action. A 10 per cent sugar solution, solutions of zinc sulphate in distilled water varying from 1 to 10,000, and calcium nitrate 1–1000, constituted the first lot of reagents. These compounds were injected into the ovaries of the plants named during the forenoon of the day at the close of which pollinations would take place, and within 24 hours of fertilization. Every precaution was taken to prevent intercrossing by guarding the inflorescences both before and after the treatments.

A common hypodermic syringe was used, and no more than a portion of a minute drop remained within the densely packed structures of these ovaries, although other plants have since been operated upon which were capable of receiving a large fraction of a cc. of the reagent. With the refinement of technic, operations are now performed with syringes in which a plunger of ground glass is ground into the barrel of a hard glass syringe, to which are attachable needles of 14k gold, by a friction tip which permits thorough cleaning. Solutions are made up in non-sol glass and kept in flasks of the same material.

In the case of the evening primroses, the tip of the needle was thrust into the ovary in a line at an acute angle with its main axis, and as a gentle pressure was applied to the plunger, the needle was gradually withdrawn. Examinations disclosed the fact that many of the ovarial structures were destroyed, the larger number

were totally unaffected, while the reagent would come into contact with a good number in such manner that it might or might not penetrate to the egg apparatus. The shock of the operation is sufficient to cause the entire ovary to be cast off in many species, and for these the method was devised later of using vapors and gases, such as bromine. The surviving ovaries were allowed to ripen in the usual manner, and the seeds duly sowed in pans of fine soil which had been sterilized in an autoclave for several hours. Singularly gratifying results were obtained from these first two plants.

The first experimental test was made with *Raimannia*. Sixteen seedlings were secured, some from ovaries treated with sugar solution, others from ovaries injected with zinc sulphate, and others with calcium nitrate, which were identical in their general characters, being, first of all, annuals in contrast with the biannuality of the parent. This entailed, of course, the continuous formation of elongated internodes from the start, the development of rosettes being due to a stage in stem formation in which the internodes are not separable by external measurements. The cycle of stem formation was therefore a simple curve, starting with a minimum for the seedling, waxing to a maximum, then decreasing with the formation of flowers in the terminal portions, in contrast with the parent, in which the curve is nearly flat for the first season, coming to zero at its end, then rising and falling as in the derivative.

Another feature no less striking was that of the glabrosity of the derivatives, the villous and ciliary hairs of the parent being wholly lacking, no trichomes whatever being formed, these plants being the only evening primroses lacking epidermal extrusions. A number of the second generation were grown, but the third generation was not brought to maturity by reason of incidents attendant upon my removal to the Desert Laboratory in 1906.

The results obtained with *Oenothera biennis* were much more conclusive, and have been followed in such manner as to leave but little doubt as to the nature and character of the changes induced. Among the seedlings grown from seeds produced by ovaries treated with a zinc solution, early in 1906, was one (erroneously given as

two in other publications) that was distinguishable as soon as the cotyledons had attained full expansion, these organs being broader and of a more vivid green, which was also characteristic of the leaves of the rosette. The plants were kept under close obervation until maturity, and guarded seeds were obtained. Every

FIG. 1.—*a*, *a*, Rosettes of induced derivatives of *Oenothera biennis* three months old; *b*, rosette of *O. biennis* of same age.

stage of their ontogeny was characterized by features which allowed them to be readily distinguishable from the parent. Successive generations were cultivated in the New York Botanical Garden, in the open, under lath shelters, in glass houses, and at the high mountain plantation of the Desert Laboratory, as well as at the Acclimatization Laboratory, Carmel, California, the close of the fifth generation now having been reached, with no diminution of the degree of divergence by which the new form was first recognized. (See figs. 1 and 2.)

The following formal descriptions were prepared from plants grown in New York under conditions as nearly identical as it was possible to secure them:

OENOTHERA BIENNIS, average form.

Mature rosette.—Leaves ample, rather copiously fine pubescent, the larger ones about 27 cm. long, 6–7 cm. wide; blades oblong to elliptic, or slightly broadened upward, unevenly repand-denticulate and most rather jagged toothed near the base, the petioles relatively stout.

Adult plant.—Plant luxuriant, mostly 1 m. tall or less; stem slightly uneven, but scarcely channeled, hirsute with spreading-ascending somewhat rigid hairs, copiously branched throughout, the lower branches decumbent, the upper ones spreading or curved upward; leaves very numerous, 1.5–2 dm. long near the base of the stem; blades elliptic-oblanceolate to elliptic-lanceolate; shallowly but rather prominently toothed, and often jagged toothed

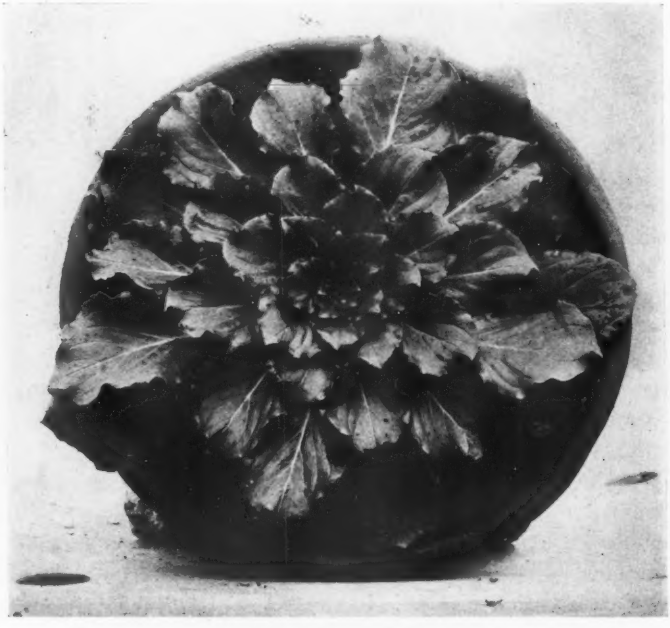

FIG. 2.—Rosette of induced derivative of *O. biennis* five months old; compare with pl. 3, Publ. no. 24, Carnegie Institution of Washington. 1906.

near the base, acuminate, those of the upper cauline leaves mostly elliptic, acute, sessile, or nearly so; bracts mainly lanceolate, narrowed or rounded at the base; conic portion of the bud 14–18 mm. long, finely pubescent, the free tips of the sepals about 2 mm. long; hypanthium 2–3 cm. long, 5–6 mm. wide at the mouth, nearly terete, sparingly pubescent or glabrate; sepals 15–20 mm.

long, much shorter than the tubular portion of the hypanthium, the free tips 4–5 mm. long; petals rather delicate, 12–16 mm. long, truncate or slightly emarginate at the apex; filaments 8–10 mm. long; anthers 7–8 mm. long; pistil shorter than the stamens; stigmas 4–5 mm. long; capsule 3–3.5 cm. long, 7–7.5 mm. in diameter at the thickest point, finely pubescent, slightly curved, markedly narrowed at the apex.[1]

It is to be seen from the above description that *O. biennis* is capable of self-fertilization by reason of the superior length of the stamens, a fact that was demonstrated in the experimental grounds. To secure purely fertilized seeds, it was only necessary to inclose the inflorescence in a parchment bag during the opening of the flowers.

DERIVATIVE.

Mature rosette.—Rosette 20 cm. or more in diameter, flat and quite symmetrical; leaves 9–13 cm. long; blades broadest above the middle, 3–3.5 cm. wide, dark green and shining above, pale beneath, minutely pubescent on veins, some of mid veins reddish above, more or less irregularly and sharply denticulate to quite near the base of the margined petioles, margins wavy, undulate, apex of the leaf somewhat twisted.

Adult plant.—Main stem 60–75 cm. high; stem stout, reddish, somewhat angled, minutely appressed-pubescent, interspersed with somewhat larger spreading cilia; branches starting from base of plant all the way up to top, numerous, 10–15 cm. long; stem leaves 7–10 cm. long, oblong-lanceolate, broadest about the middle, 2–3 cm. wide, bright green, shining above, paler beneath, and pubescent on veins, irregularly and sharply denticulate and somewhat wavy margined; bracts varying from oblong to lanceolate, those of lower branches oblong, acute, 1.5–2 cm. wide, those of upper branches 3–4 cm. long, narrowly lanceolate, acute, shining, and glabrate. (See plates XIV–XVI.)

The transference of the parent and derivative to various localities mentioned has resulted in some exceedingly interesting reactions in which fundamental differences have been displayed. In New York and Tucson, the derivative has wider leaves of a more

[1] Publication no. 24, Carnegie Institution of Washington. 1905.

vivid green than the parent, giving an effect of greater luxuriance. The derivative endures the climate of the mountain plantation better than the parent. In both places the derivative uniformly exhibits a greater amount of red in the leaves than the parent. At Carmel the reddish color is accompanied by a yellowish tinge, the green of the parent remaining practically unchanged. The parent is characterized by an excessive development of the basal

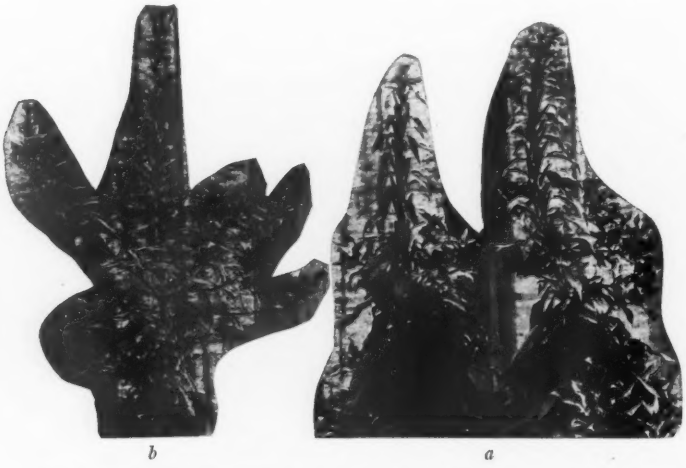

FIG. 3.—*a*, Flowering shoots of *O. biennis*, with broad leaves and short heavy upper branches, grown in equable climate of Carmel, California; *b*, flowering shoot of induced derivative, with narrow leaves and long slender uppermost branches, grown at Carmel.

branches at this place, which are heavy, robust, very leafy, and terminated by dense broad rosettes or by inflorescences. Here, as elsewhere, the capsules are longer than those of the derivative (see pls. XV and XVI) and are more noticeably angled. The derivative grown at Carmel bears numerous branches, which are longer above than in the parent, and are more ascendant, terminating in dense tufts of small reddish bractlike leaves or inflorescences. The capsules of the derivative at Carmel are generally few-seeded. This may be ascribed to the fact that the pistils here are generally longer than the stamens and are exserted from the bud, thus preventing

self-fertilization. The derivative is thus seen to differ from the parent in every stage of ontogeny and reproduction. The differences in question have been maintained through five generations and four sets of climatic and soil conditions.

A few hybridizations of derivatives with the parent have been made, with the result that the cross is found to be intermediate, being more vigorous and showing greater leaf-development than either parent, features which are also displayed in the second generation. The entire set of structural and physiological differences, together with the results of the cross with the parent, points to the conclusion that the derivative is a genotype different from that of the parental form, to which, of course, it stands most closely allied, but with which it does not intergrade.

The successes with these two forms inspired an extended range of experiments with a number of species of widely diversified morphological type, principally characteristic of the arid regions, from 1906 to the present time. Among these were included *Eschscholtzia*, *Argemone*, *Physalis*, *Covillea*, *Carnegiea*, *Mentzelia*, *Opuntia*, *Anemone*, *Amsinckia*, *Pentstemon*, *Echinocereus*, *Echinocactus*, *Sphaeralcea*, *Nicotiana*, *Fouqueria*, *Solanum*, *Kallstroemia*, *Mimulus*, *Phytolacca*, and *Brodiaea*. In addition, diligent watch has been kept for ovaries in which the stings of insects made at an early stage have resulted in serious malformations, with the view of testing probable action upon ovules contained. Only one set of seeds has been secured in this manner so far, and no deviations from the normal were found in the progeny arising from them.

In 1910 some new methods of treatment were tested, by which vapors of various substances, including bromine, were allowed to act upon inclosed inflorescences with eggs and ovules in various stages of development. The fatalities were large, but several progenies from this treatment are now under observation. Practically all plants were grown as they had become established naturally, and no effort was made to secure pollination except in one or two instances in *Pentstemon*. The proportion of losses from various causes was large in all cases. Operations were fairly successful in *Pentstemon*, but the stalks bearing ripening capsules were

harvested so completely by rock squirrels that, out of the hundreds on the slopes near the laboratory, only two or three were allowed to stand in place until the seeds were escaping from the capsules. The three surviving treated stalks of this plant that were saved were preserved by wrapping the stems in cloth. The losses in *Eschscholtzia* were very great, by reason of the quick response of this plant to injuries. *Echinocereus* failed to set a single fruit that had been treated during the first year, although quantities of seeds from treated ovaries have since been secured. Several dozens of ripening capsules of *Argemone* were destroyed by birds; *Mentzelia* matures but few seeds in each capsule; *Opuntia* fails to set fruits in many cases, owing to the injurious effects of the operation and failure to pollinate. *Carnegiea gigantea* drops many flowers that have been operated upon and fails to pollinate many, so that not more than 12 or 15 per cent of the operations were successful with this plant.

These data concerning the fatalities encountered are of interest, since they deal with plants wholly in a state of nature, and represent with fair measure the chance of survival in similar cases that might occur without human intervention.

Some attention has already been given to the conditions found in *Pentstemon Wrightii*, a small beard-tongue native to southern Arizona. This plant displays a wide range of variability in its various habitats. The plants treated on Tumamoc Hill, however, are restricted in the range of somatic characters, their progeny from treated ovaries displaying many supposedly new qualities. A most diligent observation has been made of the wild plants to distinguish naturally recurring characters from those induced. It now seems fairly certain that some new characters are found in the treated progenies. The actual examination of these forms is fraught with great difficulty, since it has not been found possible to secure fertilization in guarded inflorescences, due probably to the fact that the action of visiting insects has not been correctly imitated.

It is evident that the operations described above entail the introduction of reagents into the complex ovular mechanism, and no rational interpretation would be possible without an analysis of

the behavior of the fluid and its possible contact with the main or accessory reproductive elements. First of all, it is important to determine whether the solutions affect the egg cells or the pollen elements, and a number of tests were made with dyes for this purpose. The large ovaries of the giant cactus (*Carnegiea gigantea*) offered some excellent opportunities for testing these points.

The introduction of reagents into the ovaries of this plant was accomplished by thrusting the tip of a needle of a syringe diagonally downward into the cavity through the wall, and then by a steady pressure of the plunger perhaps as much as 0.4 to 0.6 cc. of solution was forced in, setting up a pressure that in some instances increased the external dimensions of the ovary, and the withdrawal of the needle was often followed by the ejection of some of the fluid, but the high turgidity of the walls soon closed the aperture or perforation.

The flowers of *Carnegiea gigantea* ordinarily open in the morning and attract a variety of bees and small gnats, the former probably being instrumental in pollination. Plants taken to the New York Botanical Garden in 1902 did not set seeds unless pollinated by hand. The flowers open in the morning and close with the day when the temperature is above 80° F., but on cooler or cloudy days the flowers may remain open during a part or all of a second day.

The style is as much as 5 or 6 cm. in length, and the pollen tube arising from grains falling on the stigmatic surfaces seems to take nearly a day in effecting fertilization, although exact observations on this point could not be made. It was deemed best, therefore, to inject solutions into the ovaries at any time between 10 A.M. and 4 P.M., thus securing the possibility of affecting the egg apparatus, or the pollen tube as it advanced.

The introduction of methyl blue at this time was followed by its absorption by the inner walls of the locule, and its conduction to the apex of the ovarial cavity at the base of the style in such manner that entering pollen tubes must pass through the impregnated layer, and would be subject to the action of free coloring agent, whether traveling intracellularly or intercellularly. That

it was colored was proved by examination of material a day later, when many stained filaments could be seen. Beside this, the stain was taken up by the concave flanks of the ultimate placental branches which were stained very deeply, and which by their conductive action carried a large quantity of the reagent into the ovule, where it spread between the outer and inner integuments, but it was separated from the nearest portion of the egg apparatus by several layers of cells. Micropylar structures were stained but sparingly when the reagent was introduced into the bases of opening flowers as above.

If, however, the injection was made on the day previous to the opening of the flower or earlier, the placental stalks were not stained so deeply, the amount introduced into the ovule being very small or mostly none at all. On the other hand, the inner integument at the micropylar orifice was deeply stained, so that any pollen tube entering through this structure would certainly encounter the reagent. The conducting tissue on the inner surface of the locule was deeply stained at this stage, and by its action much of the color was conducted to the apical region through which the pollen tube must pass.

It is to be seen, therefore, that the placental stalk presents a concave flank most highly absorbent and conductive at the time that the egg apparatus is complete and awaiting fertilization. Before this time, the introduction of a reagent results in greater affection of the endostome and greater accumulation of the coloring matter in the basal portion of the pistil through which the pollen tubes must pass. The probabilities would be greatly in favor of a reagent acting upon the pollen nucleus when introduced at this stage, to the total exclusion of any direct effect upon the embryo sac. Injections on the day of fertilization, at a time when most of the successful operations were performed, resulted in some of the solution going into the ovular structures, but not into such close contiguity that the embryo sac might be supposed to be affected. In a few instances the endostome was also stained, while the tissue through which the pollen tubes pass into the locule accumulated the reagent.

Oenotheras were injected with methyl blue at the Desert

Laboratory in June 1907 to ascertain the probable mechanical effects by which divergent derivatives had been induced in two genera. Colored solutions introduced into the ovaries the day before fertilization showed but meager effect in comparison with the actual results of injection in the cactuses. The stain was found adhering to the outer layers of the ovule, in which the embryo sac lay deeply buried. In no instance was anything like a marked penetration observed. The placental stalks were stained in a few instances, and rather deeply, and this offers the only shadow of a clue as to possible effects of the introduced reagents. The number of ovules affected in any way well accords with the comparatively meager effects secured. It was noted also that the rupturing of the ovarial walls freed numbers of crystals of calcium carbonate, which were partly dissolved by many of the reagents and would thus complicate hypothetical reactions.

The introduction of methyl blue solutions into ovaries of *Mammillaria* on the days the flowers were opened, resulted in staining the papillar cells which project from the sharp angles of the funicular or placental stalk, which is curved in such manner that a pollen tube would pass among them, probably coming into the closest contact with their mucilaginous walls. Here, as in *Carnegiea*, the introduction of a foreign substance would place the greatest chance of affection of the germinal elements within the pollen tube. Further tests were made with a solution obtained by allowing powdered carmine to stand in distilled water. The introduction of the reagent into the ovaries of the flowers that had opened was followed by a general absorption of it by the absorptive cells of the concave flanks of the funicular stalks, and by the underlying cells, with only a slight affection of the ovule and only an occasional reaction from endostomes. Injections of flowers the day before opening, however, gave more marked results. In this case, not only was the dye taken up by the conductive systems lining the locules as in the case above, but the stain had traveled up the base of the pistil for as much as a centimeter. Furthermore, the reagent was not only taken up in quantity by the funicular stalk, but it had been conducted into the ovule, where much of it had accumulated between the outer and inner integu-

ments. Beyond this it could not be traced, although it seems reasonable to suppose that some action extended beyond. At the same time, numerous endostomes could be detected which had taken on a marked stain. Not only were the external cells colored, but the action extended inward some distance.

The study of the movements of dyes yields some profitable suggestions as to the probable mechanical movements of reagents introduced into ovaries for the purpose of affecting the egg apparatus or the pollen tube. The coloring matter was not seen to penetrate farther than a point separated by five or six protoplasts from the egg nucleus. The pollen tube carrying the fertilizing nucleus, however, may be compelled to pass through or among cells taking up any foreign substance, so that only the two walls and the cytoplasm intervened. It seems, therefore, that the greater weight of probability lies on the side that the proembryonic affectation of the germinal elements of a seed plant is one in which the possible changes are to be supposed to be due to the action of the reagent on the pollen nucleus rather than on the embryo sac.

The care of treated plants until the seeds in treated ovaries have matured and may be harvested has absorbed much effort, since in many species the plants may ripen a few seeds daily, and collections must be made frequently. Next after the harvesting of the seeds, sowings must be made at the proper time of the year. In the case of species of the desert it has not been found profitable to attempt germinations except at the customary time, else enormous fatalities may occur. Many of the forms which offer particularly favorable conditions for ovarial treatments are slowly developing perennials, which need several years to reach the stage in which they may produce seeds and thus furnish a second generation.

At the present time, seedlings from treated ovaries are under observation as follows: *Echinocereus Fendleri*, *Echinocactus Wislizeni*, *Brodiaea capitata*, *Fouqueria splendens*, *Sphaeralcea pedata*, *Pentstemon Wrightii*, *Phytolacca decandra*, *Opuntia discata*, *Carnegiea gigantea*, *Amsinckia spectabilis*, and *Solanum eleaegnifolium*. Of these, lots from successive seasons are under observa-

tion from two species, in which some species are represented by two or more different treatments.

The announcement was made in 1908 that some divergent characters were seen in a treated progeny of *Cereus*. The plant in question, by the incessant changes of nomenclature, is known at the time of this writing as *Echinocereus Fendleri*. The progeny is coming into bloom, and while one of the individuals diverges widely beyond the observed range of fluctuating variability, it cannot yet be definitely stated whether or not the characters displayed are permanently heritable or not. The individual in which they are represented is of normal vigor, and is not in any ordinary sense monstrous or teratological.

It may be readily apprehended that any theoretical interpretation of the action of the reagents employed in this series of experiments is extremely difficult. The question as to whether the embryo sac or the generative nucleus of the pollen tube is acted upon is, withal, a purely mechanical consideration. The real problem is the nature of the alterations induced by the action of the compounds to which the test plants are subjected.

Some of the earlier results with *Raimannia* were obtained with solutions of cane sugar, not of tested purity, however, and applied with built-up metal syringes, and corrosion may have occurred to such an extent as to make the action similar to that in which solutions of metals and halogens were used in proportions of 1 to 10,000 or 1 to 50,000 of distilled water. The application of zinc and iodine solutions in the more carefully guarded operations may have affected the reproductive protoplasts in various ways. The chief difficulties in the way of theoretical interpretations consist in the fact that the direct action of the reagents cannot be followed in the deeply buried reproductive elements. It can only be said that the reagents might alter the dissociations in the cell, while not entering it, or perhaps only in the minutest quantities, and the properties of an egg might well diverge with changes in the relative number of free ions of various kinds in its compounds. This assumes, of course, a direct connection between the chemical constitution of the cell and the properties it displays. The entire effect might be due simply to altered

permeability of the limiting membranes of the protoplasts or of the vacuolar sacs.

Experimental studies such as are here described lead the investigator into the consideration of two phases of the subject. One is concerned with the demonstration of induced hereditary alterations and the study of their behavior in pedigreed strains, in hybridizations, and under various environic conditions. The other includes a consideration of the mechanism by which an environic agency affects the physical bearers of heredity. Both comprise some important and interesting possibilities in evolutionary science.

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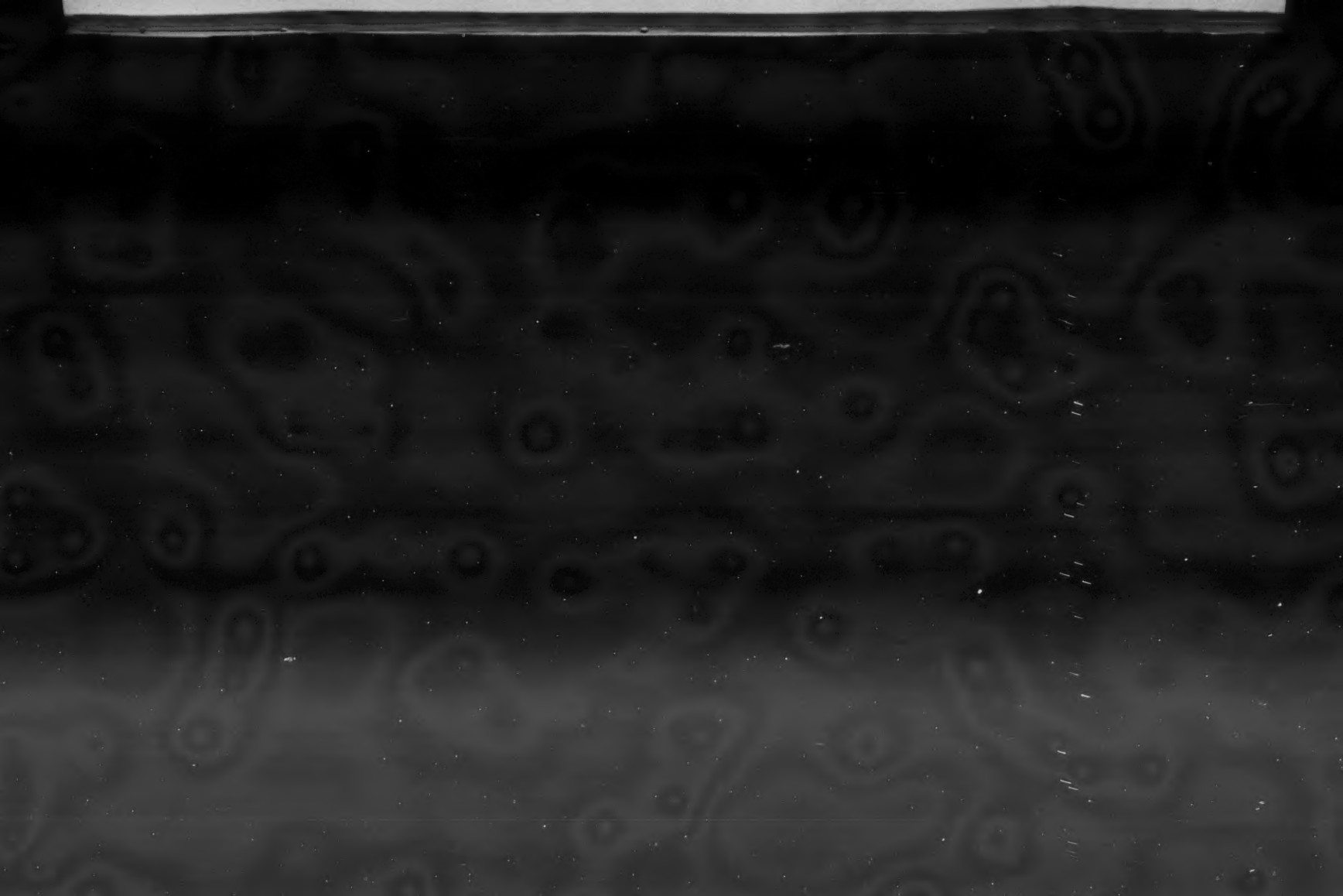
EARLIER PAPERS BY THE AUTHOR ON RESULTS OF OVARIAL TREATMENTS

1. Heredity and the origin of species. Monist, Jan. 1906; reprinted in advance Dec. 1905, and as Contribution No. 80 of the New York Botanical Garden, 1906.
2. Heredity and environic forces. Vice-presidential address before Section G, A.A.A.S., at Chicago meeting, Dec. 30, 1908; reprinted in advance of annual volume.
3. Heredity and the origin of species. Smithsonian report for 1908, pp. 505–523; issued in 1909.
4. Physiology of genetics. Sixth year book, Carnegie Institution of Washington, p. 62, 1907; seventh year book, p. 63, 1908.
5. Alterations in heredity induced by ovarial treatment. Eighth year book, Carnegie Institution of Washington, p. 59, 1910.
6. The direct influence of environment. Fifty years of Darwinism, p. 114, 1908.
7. Origination of self-generating matter and the influence of aridity upon its evolutionary development. Outlines of geologic history, by WILLIS and SALISBURY, p. 278, 1910.
8. Environic response. Amer. Nat., Jan. 1911; also Science, Jan. 20, 1911.

EXPLANATION OF PLATES XIV–XVI

PLATE XIV.—*A*, rosette of *Oenothera biennis* at Desert Laboratory, 1910; *B*, rosette of induced derivative.

PLATE XV.—*Oenothera biennis: 1*, leaf from young rosette; *2*, leaf from rosette four months old; *3*, leaf from lower part of mature rosette; *4*, leaf



MACDOUGAL on OVARIAL TREATMENTS

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from upper part of mature rosette; *5*, stem leaf; *6*, bract; *7*, unopened bud; *8*, flower with petals removed; *9*, petals of maximum size; *10*, mature capsule; *1–5*, one-half natural size; *6–10*, natural size.—From Publ. no. 24, Carnegie Institution of Washington. 1905.

PLATE XVI.—Derivative of *Oenothera biennis:* *11*, leaf of young rosette; *12*, leaf from mature rosette; *13*, leaf from mid-stem; *14*, leaf from upper part of stem; *15*, bract; *16*, flowering branch; *17*, flower stripped of corolla; *18*, petals; *19*, capsule and bract.

SOME FEATURES OF THE ANATOMY OF THE FOLIAR BUNDLE[1]

EDMUND W. SINNOTT

(WITH PLATE XVII)

Although the vascular system of the leaf in the Cycadaceae has for some time been recognized as a region where primitive structures, notably centripetal wood, have persisted longer than anywhere else in the plant, the general principle of the conservatism of the foliar organ has only recently been more widely extended and found to hold good for all the main groups of vascular plants: Lycopsida, Filicales, Gymnosperms, and Angiosperms. The position of the protoxylem in relation to the later formed elements of the wood is very constant in the large orders, but its importance in determining phylogenetic relationships seems often to have been overlooked. A brief summary of the structure of the leaf trace and foliar conducting system of all families of vascular plants, with special reference to the position of the protoxylem, and a more particular account of conditions in the living Cycadaceae, the only existing gymnosperms with centripetal wood, together with a discussion of the bearing of the results on our views as to the evolutionary history of the higher plants, is the purpose of the present paper.

That the base of the leaf trace, since it is least subject to changes in external conditions, should retain ancestral structures longer than does any other portion of the foliar system seems logical, and this has been proven to be true in several groups of vascular plants. It is therefore in this region that we should look for the primitive structure of the foliar bundle.

In all the Lycopsida where the anatomy of the leaf is known (*Equisetum*, *Lycopodium*, *Selaginella*, *Phylloglossum*, *Tmesipteris*, *Psilotum*, *Isoetes*, *Lepidodendron*, and *Sigillaria*), the vascular strand at the base, and in the majority of instances throughout the lamina, of the leaf, is a single concentric strand, roughly circu-

[1] Contribution from the Phanerogamic Laboratories of Harvard University, no. 33.

lar in cross-section, and with one median mesarch[2] protoxylem group. This condition also occurs at the base of the leaf trace in the Osmundaceae and Ophioglossaceae, and it apparently is present at the node of the Botryopterideae (1), and therefore seems to have been the primitive one for these families. It is very evidently the earliest type of foliar strand in vascular plants, and has persisted almost unchanged in the microphyllous Lycopsida, but in the megaphyllous Pteropsida has undergone extreme modification.

A very ancient type of leaf bundle has recently been investigated by BERTRAND in his account of the anatomy of the leaf in the Zygopterideae (1), one of the three families of the Botryopterideae, those simple protostelic ferns which clearly stand close to the ancestors of the modern Filicales. The early condition of the leaf trace in this group is of importance as representing the primitive one for all ferns. This has been found by BERTRAND in the simpler forms of the Zygopterideae, such as *Clepsydropsis* and *Asterochlaena*. These genera possess a leaf bundle which is concentric and rather elliptical in shape, and which contains at either end an island of parenchyma imbedded in the xylem. Around the island are placed the protoxylem elements, which are irregularly scattered in the former genus and in two distinct groups in the latter. BERTRAND has established a very complete series of forms between this type of leaf strand and the more complicated bundles of the remaining Botryopterideae, all of which seem clearly to have been derived from the simple diarch and mesarch condition. The original monarch structure persists at the base of the trace.

In a recent paper (9) the writer has endeavored to show how the leaf bundle of the modern Filicales has been developed from that of these primitive Zygopterideae. Aside from the change in shape and the breaking up of the strand into separate bundles, the most notable difference between the modern forms and their ancestors

[2] The term "mesarch," as used in the present paper, is descriptive of any protoxylem group, whether situated at the axis of the stem or not, which is surrounded by metaxylem. "Endarch" describes any condition where the protoxylem is not at the axis and where there is no metaxylem (centripetal wood) formed on its inner face. "Exarch" describes any condition where all the primary metaxylem is formed on the inner or adaxial side of the protoxylem.

is in the position of the protoxylem. In the petiole of every living genus of ferns except *Lygodium*, the first-formed tracheids are endarch, and the upward development of the filicinean leaf seems to be uniformly marked by the disappearance of its centripetal wood. At the base of the leaf trace in many ferns a mesarch condition still persists. Here the protoxylem is usually simply mixed indiscriminately in the metaxylem, but in those rather rare cases where it shows a definite attachment either way, it almost always becomes continuous with the centrifugal wood. The base of the leaf trace of *Thamnopteris*, a primitive osmundaceous fern, as described by KIDSTON and GWYNNE-VAUGHAN (**3**), is a good example of this. Endarchy and the attachment of the protoxylem to the centrifugal wood are therefore distinctive characters of the advanced filicinean foliar bundle.

The close affinity of the Cycadofilices to the ferns is manifest in the structure of the leaf trace as well as in many other characters, and there seems good reason to believe that the foliar strand in this group of early seed plants has been derived from a bundle very similar to that of *Clepsydropsis* or *Asterochlaena*.

The most primitive genera of the Cycadofilices and those which approach the ferns most closely in all their characters are *Calamopitys*, *Lyginodendron*, and *Heterangium*. In *Calamopitys*, which is a very ancient form, going back to the Devonian, the base of the leaf trace, while still one of the bundles which surrounds the pith, is a single strand, with a cluster of protoxylem mixed with parenchyma at its center. In most species the centripetal wood becomes reduced at the very base of the bundle, and in *C. Beinertiana*, as described by SCOTT (**5**), it is actually broken through, the protoxylem becomes continuous with the centrifugal wood, and an endarch condition results. As the single mesarch trace leaves the stele, its protoxylem group divides into two parts, which lie near the outer face of the bundle, and each of these soon divides again into two. The trace on becoming free splits equally into two diarch, mesarch, and concentric strands, which pass out through the cortex. In the base of the petiole these split up into an arc of six bundles. The primitive monarch condition is therefore present at the very base of the trace; this soon takes on the diarch structure

of *Clepsydropsis;* and this in turn assumes a tetrarch condition, the striking similarity of which to the bundle of *Asterochlaena* has been noted by BERTRAND. It is noteworthy that the typical modern fern character of endarchy is present only in the stem. In the leaf trace in the cortex, the first formed elements of the wood seem to be clearly connected with neither face of the bundle.

Conditions in *Lyginodendron* are very similar. The trace at its base is monarch, and though true endarchy apparently never occurs in this genus, the protoxylem group, which lies near the outer edge of the bundle on the abaxial side of an immersed island of parenchyma, is always continuous and in seriation with the narrow arc of centrifugal wood. This relation of the protoxylem to the metaxylem persists throughout the course of the leaf trace in the cortex, but is apparently lost in the petiolar bundle, where the earliest tracheids show no definite attachment to either the inner or the outer wood.

The single protoxylem group soon divides into two (fig. 6), as in *Calamopitys*, and the trace in a short time also separates into two equal parts, which shortly become diarch. These four clusters of protoxylem are all near the outside of the metaxylem, but are seriated with the centrifugal wood if at all. In the petiole the two strands become united by their abaxial ends into a tetrarch arch, which becomes gradually wider and more flattened and soon contains eight to ten protoxylem groups, all of which are clearly mesarch. This wide bundle often becomes divided into several distinct strands, which in the upper part of the rachis come together into a tetrarch and finally triarch and mesarch bundle, such as is figured by SCOTT in his description (**6**). It is noteworthy that in the petiole and rachis the abaxial elements are always smaller than the adaxial ones, a condition which is often found in the leaves of living ferns.

The structure of the trace in *Heterangium* is very similar to that in *Lyginodendron* except that it often remains undivided. The mesarch protoxylem here as well as in the stele is always in seriation with the centrifugal wood.

It is clear that in these three genera we have to deal with plants showing a strikingly close resemblance in the lower and more

primitive portions of their leaf bundles to conditions which prevailed in the foliar strands of the early Botryopterideae, and it seems reasonable to suppose that this resemblance indicates a phylogenetic relationship between the two groups. These cycad-ferns, however, show their advanced condition by the possession of a much more complicated petiolar system, and by displaying the tendency shown by modern ferns for the protoxylem to become continuous with the centrifugal wood and to be at last completely endarch.

The remaining Cycadofilices show a very different structure in their leaf bundles. Here the progression, instead of being toward endarchy, is all toward exarchy, and the primitive mesarch trace with protoxylem near the outside loses its narrow zone of centrifugal wood, and its protoxylem becomes continuous with the centripetal wood, thus forming a direct contrast to the trace of *Lyginodendron*. The *Myeloxylon* type of bundle characteristic of the petioles of *Medullosa* and *Sutcliffia* shows clearly this exarch condition, though *Colpoxylon*, which often possesses only a single vascular cylinder in its stem and which is therefore probably more primitive than the other two genera, shows traces of centrifugal wood and the ancient mesarch structure. In all these genera the petiolar vascular system consists of a large number of bundles more or less irregularly arranged, but, in *Medullosa* at least, the base of the leaf trace is a single strand possessing one or more groups of protoxylem which seem to be slightly imbedded in the metaxylem.

In *Megaloxylon* the base of the leaf trace is the only part of the foliar strand of which the structure is known, and it is here a single exarch bundle.

Ptychoxylon Levyi, one of the Cycadoxyleae, shows a closer approach to the primitive Cycadofilices, for here the trace is a double one, each part of which, however, instead of being mesarch is clearly exarch.

In those primitive gymnosperms of the Palaeozoic included in the cordaitean alliance, we find the same exarch structure in the leaf bundle, which almost always consists at its base of two strands. In *Poroxylon* this pair of monarch bundles, which ultimately unite at their very base, are carried well down into the stele,

the primary wood of which is thus entirely centripetal. In the petiole and blade of the leaf, the double trace divides into a series of parallel strands, each of which possesses a mass of exarch primary wood, on the outer side of which, except at the edges of the leaf, is a zone of secondary xylem, just as in the leaves of living cycads.

In *Mesoxylon*, a new genus recently established by SCOTT and MASLEN (**7**) to include forms intermediate between *Poroxylon* and the Cordaiteae, we see in the stem the beginnings of the endarch condition of the higher gymnosperms. The double leaf trace is still exarch, the protoxylem being in seriation with the centripetal wood which, in the very lowest part of its course, in several species, becomes much reduced and may finally disappear, leaving as the only relic of the primary wood the cluster of protoxylem, which is separated by parenchyma from the centrifugal secondary xylem. The structure of the leaf trace and foliar bundles in this genus is the same as in *Poroxylon*.

In the case of Cordaites, however, the typical stem structure of the modern gymnosperms makes its appearance, for here the protoxylem attaches itself to the centrifugal wood, which is almost, if not quite, entirely secondary. In the double leaf trace, however, well developed centripetal primary wood appears, with exarch protoxylem on its outer face. In the leaf blade the veins are clearly exarch. In certain species centrifugal xylem is present here, separated by parenchyma from the protoxylem and probably secondary in origin, but this is absent in the simpler forms such as *C. principalis*, where the structure is strikingly like that of a *Medullosa* bundle.

There are certain other fossil plants, probably rather closely related to *Poroxylon* and the Cordaiteae, which possess a somewhat similar type of leaf trace and primary wood, and which have been grouped by SCOTT under the family name of Pityeae.

In the genus *Pitys* the trace shows signs of bifurcation as it passes out, and it is clearly mesarch, as are the medullary strands of primary xylem. The bundles are all small, however, and the protoxylem shows no tendency to align itself with either the centrifugal or centripetal wood, showing in this respect a primitive condition.

Dadoxylon Spenceri shows considerable resemblance to *Poroxylon*, for its leaf trace, at first single, becomes double before leaving the stele, and possesses well developed primary centripetal wood, on the outer face of which occurs the exarch protoxylem. At the very base of the trace, however, this primary wood disappears and an endarch condition results.

It seems highly probable that the living Coniferales have been derived from plants closely related to the Cordaitales, but that, in the course of their development, the modern members of the group have almost entirely lost the centripetal primary wood so characteristic of their ancestors. In the cretaceous genus *Prepinus*, however, JEFFREY (**2**) has recently described an intermediate condition between ancient and living forms, for in the leaf of this primitive pine there is abundant centripetal wood. Though the protoxylem is adjacent to this, it is apparently in seriation with the centrifugal part of the bundle, which is very probably modified secondary xylem, as indicated by the presence of abortive medullary rays. In this case, apparently, the first-formed tracheids had assumed the typical coniferous position before the disappearance of the centripetal xylem. We shall find a very similar condition at the base of the petiole in living cycads.

Among the higher modern gymnosperms, the only occurrence of centripetal wood is in *Ginkgo*, where it is present as scattered tracheids, not in connection with the protoxylem, in the cotyledons, vegetative leaves, and anthers. This genus, which on other evidence is accounted one of the most primitive of the existing gymnosperms, also possesses a double leaf bundle and a wide, parallel-veined, rather cordaitean lamina.

The occurrence of a double foliar strand, in the more ancient of the living conifers, seems without much question to be the persistence of such a double trace as is found at the base of the leaf in the Cordaitales. The double foliar bundle found by Miss THOMAS (**12**) in the seedlings of many angiosperms is probably also an indication of a primitive condition. The leaf trace in the adult members of this group takes on a great variety of forms, and never displays the true centripetal xylem or "cryptogamic wood" of the early gymnosperms.

The mesozoic Cycadophyta, exemplified by the two genera *Cycadeoidea* and *Bennettites*, though showing in their cauline central cylinders the endarch condition characteristic of modern cycads and other gymnosperms, still possess primitive features in their leaves. The foliar trace as it departs from the stele is a single arched bundle. In the base of the petiole of *Cycadeoidea*, as observed by WIELAND (**13**), and of *Bennettites Gibsonianus*, as observed by SEWARD (**8**), there is a considerable amount of primary centripetal wood and of radially arranged secondary centrifugal wood, with protoxylem between the two. The seriation of the protoxylem is impossible to make out, but it was doubtless exarch, as in modern cycads. The centrifugal wood apparently diminished in amount in the upper part of the petiole. The structure of the vascular bundle in the lamina of the leaf is described by WIELAND in *Cycadeoidea* as "mesarch" and very similar to that in living cycads.

Certain recent discoveries by Miss STOPES and FUJII are of importance in this connection. The leaf blade of *Niponophyllum*, as described by these authors from the Cretaceous of Japan (**11**), is parallel veined and possesses collateral exarch vascular bundles with no centrifugal wood, thus presenting a very close resemblance to certain of the more simple types of leaf among the palaeozoic Cordaitales.

In *Nilssonia orientalis*, another Japanese cretaceous form described by Miss STOPES (**10**), the leaf blade is pinnate, having a strong midrib from which come off parallel lateral veins. The vascular strands here also seem to be clearly exarch, with no trace of centrifugal wood. The structure of the stele and of the leaf trace in neither of these forms is known.

The living Cycadales show a close resemblance anatomically to the palaeozoic Cycadoxyleae, notably *Ptychoxylon*. The central cylinder of the stem is always endarch with no centripetal xylem, save for a few scattered tracheids, not connected with protoxylem, in the reproductive axes of certain species. The leaf trace departs as a double bundle, the halves of which soon separate and pass around the stem in opposite directions before entering the base of the leaf, where they divide into a many-bundled arch. Very

primitive structures are retained, as in so many former cases, only in the petiole and blade. The vascular anatomy of this portion of the plant, with special reference to the position of the protoxylem, was investigated by the writer in a considerable number of species.[3] The results obtained agree in general with those of METTENIUS (**4**) and other later investigators.

At the very base of the leaf trace in all the species the primary wood becomes increased in amount at the flanks of the bundle, and two adaxial projections are here formed which finally unite behind the original position of the protoxylem and inclose a small island of parenchyma. The protoxylem either follows one or both of these masses of metaxylem backward, always remaining attached to them, or else swings over to the centripetal wood as soon as the two arms of the latter unite. Just before this change takes place, the bundle presents a close similarity to that of the leaf of *Prepinus*, for both centripetal and centrifugal wood are well developed, and the protoxylem is in seriation with the latter (fig. 5).

The centrifugal wood becomes very rapidly diminished in amount as the bundle ascends, so that in the middle and upper portion of the petiole in many species, such as *Zamia integrifolia* and *Encephalartos Altensteinii*, it is either absent in most of the strands or represented by only two or three elements (fig. 2). It is also noteworthy that, except perhaps at the very base of the petiole, this outer xylem seems to be entirely secondary, as is shown by its relation to the phloem. All but the extreme outer part of this latter tissue is clearly secondary and radially arranged, and the centrifugal tracheids are almost always just at the inner ends of the rows of phloem elements, and seem unquestionably to have been produced by the same cambial activity (figs. 1 and 3). They are usually pitted and not scalariform, as are most of the elements of the centripetal xylem.

[3] These include Cycas verticillata, C. media, C. celebica, C. ruminiana, C. circinalis, Zamia furfuracea, Z. macrophylla, Z. Loddegesii, Z. integrifolia, Z. Skinneri, Z. Linderi, Z. muricata, Z. Seiboldii, Ceratozamia latifolia, C. mexicana, C. kuesteriana, Encephalartos horridus, E. Altensteinii, E. Lehmanii, Microzamia spiralis, Dioon edule, and Bowenia spectabilis.

The protoxylem is always attached to the primary centripetal wood, which forms the great bulk of every bundle, and it is clearly in seriation with it, the smallest and ringed elements being on the very outside and becoming successively closely ringed, spiral, and pitted as we approach the inner or adaxial edge of the strand (fig. 4). Between the protoxylem and the centrifugal wood there is in nearly every case a row of parenchyma, one or two cells wide, just as in the cordaitean leaves which possess centrifugal wood. The petiolar bundles may vary in shape from narrowly triangular, with the protoxylem carried up on the apex, to almost semicircular, with the first formed tracheids in the middle of the flat upper side.

The resemblance of a cycad leaf bundle to the foliar trace of *Lyginodendron* has been much emphasized by SCOTT and others. There are apparently two very vital differences between the two, however, for the former has no centrifugal primary wood, as has the latter, and in the cycad leaf the protoxylem is distinctly seriated with the centripetal xylem, and not with the centrifugal, as it is in *Lyginodendron*. The one is exarch and the other mesarch with a tendency toward endarchy. Scattered bundles were observed in several species, where the protoxylem connected the inner with the outer wood, being attached to both. Such cases are doubtless reduced and due to the partial abortion of the separating zone of parenchyma. In all of them the protoxylem remained in seriation with the centripetal wood.

In the leaf blade the centrifugal secondary wood is still further reduced, especially when the bundles become small at the end of a pinna. In several species, such as *Dioon edule*, it is altogether absent, and in no case is it represented by more than three or four cells. These often lose their radial arrangement and tend to cluster round the outer face of the protoxylem cluster. This gives the mesarch appearance, which is probably similar to what WIELAND saw in the blade of *Cycadeoidea*. In the small cotyledonary traces of *Bowenia*, WORSDELL observed a true mesarch structure, which may perhaps be a reversion to the very primitive botryopteridean condition.

Conclusions

The following general phylogenetic conclusions may be drawn from a study of the leaf trace and foliar bundle of vascular plants.

The primitive foliar bundle was a single monarch and mesarch vascular strand. This has persisted in the leaf trace of all the Lycopsida and in the blade of many of them, thus furnishing further evidence of the unity of the group and of its relatively primitive position.

This type of bundle is present at the base of the leaf trace in the Osmundaceae and in certain of the Ophioglossaceae, which thus seem to have been early separated from the other ferns.

The leaf bundle of the primitive palaeozoic Filicales was a diarch and mesarch one. By the disappearance of its centripetal wood, this has given rise to the endarch foliar strands of living ferns, which have apparently been derived from the more ancient of the Botryopterideae.

The diarch and mesarch leaf bundle is also the primitive one for the seed plants, which were developed along two main lines from forms related to the early Botryopterideae, but which had acquired the seed habit. The members of the first series, including *Calamopitys*, *Lyginodendron*, and *Heterangium*, show the fern tendency for the protoxylem of the stele and leaf trace to become continuous and in seriation with the *centrifugal* wood, and for an ultimately endarch condition to result. The other series, which includes all remaining gymnosperms, and probably the angiosperms, shows in its earliest and most primitive forms the tendency in the vascular system of the stem and leaf for the protoxylem to become continuous and in seriation with the *centripetal* wood, and for an ultimately exarch condition to result.

These two groups are also clearly separated on other evidence. The endarch series are very fernlike in habit, possess seeds of a peculiar type, and show in their petiolar bundles (at least in *Lyginodendron*) that ancestral mesarch condition of the Botryopterideae where the protoxylem shows no preference for either the inner or the outer wood. The early members of the exarch group, however, such as *Medullosa*, do not show such striking resemblances to the ferns, possess seeds of a higher and more

cycadean type, and display an exarch condition not only in the leaf trace but throughout the petiolar system.

The double trace is clearly present in the endarch series, and is also found in most of the exarch forms, including the higher Cycadofilices; *Poroxylon*, *Cordaites*, and their allies; many modern conifers, and the living Cycadales. It seems clearly to have been a primitive character, and to have arisen from a constriction of the single diarch strand which was present in the ancestors of all seed plants.

The endarch line of development apparently ended blindly and did not give rise to the typically endarch higher plants, which were developed along several distinct lines from a plexus of forms in the exarch group possessing a double leaf trace and seeds resembling those of *Medullosa*.

The Poroxyleae, Pityeae, and Cordaiteae came from this plexus at a very remote period. The tendency among this series has been toward the development of a parallel veined leaf, a clearly gymnospermous type of reproduction, and an endarch condition of the central cylinder, together with a wide zone of secondary wood.

The parallel venation of the leaf has doubtless been derived from a pinnate condition, with a two-bundled exarch rachis, a structure which has persisted only at the base of the trace. The cordaitean type of leaf seems to have existed in the Cretaceous, as is shown by the occurrence at that period of such forms as *Niponophyllum*. The genus *Nilssonia*, possessing a simple leaf with a distinct midrib but with clearly parallel lateral veins, shows an intermediate condition between a pinnate cycadean leaf and a parallel veined condition, and gives a suggestion as to how the latter may have been produced.

The cordaitean type of reproduction is unknown in the Cycadofilices, but *Trigonocarpon*, the seed of *Medullosa*, approaches closely the seeds of the Cordaiteae.

The endarch condition of the central cylinder has been caused by the disappearance of the centripetal primary wood of an exarch stem consequent upon the great increase in bulk of the centrifugal secondary wood, to which the protoxylem has finally attached itself.

A second line from the double-bundled *Medullosa*-like plexus of

the exarch group, but one which lies close to the cordaitean alliance, has given rise to the Ginkgoales, the Coniferales, and probably the angiosperms. Centripetal wood persists here only in *Ginkgo*, and in the leaves of such ancient conifers as *Prepinus*. Endarchy is apparently elsewhere universal, although our knowledge of conditions in the earlier forms is very slight. *Ginkgo* and the more primitive coniters possess a double foliar bundle, and all members of both groups have parallel veined leaves. The double bundle also appears in seedlings of certain angiosperms, but this series has otherwise departed very widely from its palaeozoic ancestry.

A third line from our ancient stock gave rise to the cycad-like Bennettitales which flourished in the Cretaceous. The foliar trace here was a single bundle—either the primitive single strand, perhaps comparable to that of *Medullosa*, or a fusion of two—which developed in the petiole and blade into a series of typically exarch bundles with centrifugal secondary wood. The reproductive organs were very specialized, and the group has probably given rise to no living family of plants.

The modern Cycadales perhaps constitute a fourth line from the palaeozoic plexus which, however, lies very close to that of the Bennettitales. They have often been considered as derived from forms related to the Lyginodendreae, but the exarch structure of the leaf bundles and the construction of the seed, which is much more comparable to that of *Medullosa* than to that of *Lyginodendron*, make it very improbable that the latter genus has given rise to the modern family. The cycads are also separated from the Bennettitales by the possession of a double leaf trace and a simple reproductive system. The parallel venation of the leaf suggests the Cordaitales, and, as we have remarked above, *Nilssonia* shows an intermediate condition between the two types of leaf.

It seems probable that the group arose in the late Carboniferous from cycad-ferns possessing a double exarch leaf trace and petiolar bundle, a type of leaf intermediate between the ordinary fern frond and the parallel veined cordaitean condition, and a seed resembling that of *Medullosa*.

There are thus apparently two main groups in the exarch series,

one of which has progressed toward the coniferous type, and is represented by the Cordaitales and the modern Coniferales, and the other of which has produced the cycadean type, as represented by the Bennettitales and the modern Cycadales.

The writer is under much obligation to the authorities of the Royal Botanic Gardens at Kew and of the Botanic Garden of Harvard University for material. He also wishes to express his thanks to Professor E. C. JEFFREY for advice during the course of the work.

This investigation was carried on in the Phanerogamic Laboratories of Harvard University.

HARVARD UNIVERSITY

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EXPLANATION OF PLATE XVII

FIG. 1.—Petiolar bundle of *Cycas revoluta*, showing the typical cycadean condition, with primary and secondary phloem, primary centripetal xylem, and secondary centrifugal xylem; ×150.

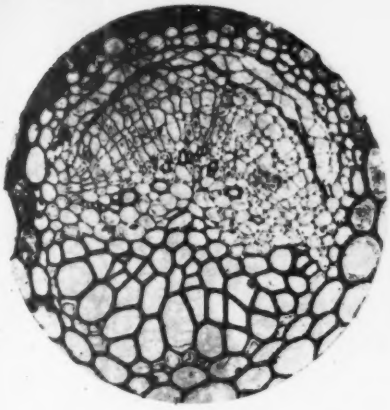
FIG. 2.—Typical petiolar bundle of *Encephalartos Lehmanii*, showing complete absence of centrifugal wood; ×250.

FIG. 3.—Petiolar system of *Zamia Loddegesii*, showing the small amount of centrifugal wood and its radial arrangement.

FIG. 4.—Longitudinal section of a bundle of *Cycas revoluta*, with centrifugal wood on the left and centripetal wood on the right; the protoxylem is clearly in seriation with the latter; ×100.

FIG. 5.—Bundle from the base of the petiole of *Zamia macrophylla*, showing the protoxylem attached to both centrifugal and centripetal wood; ×120.

FIG. 6.—Leaf trace of *Lyginodendron* at its separation from the stele, showing the diarch condition; ×40.



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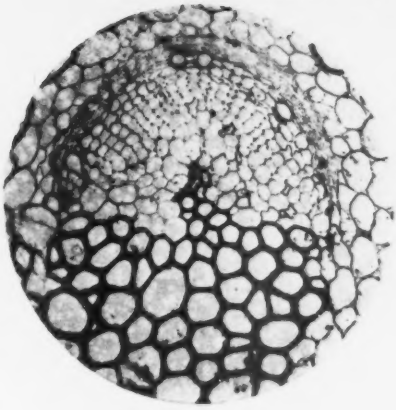

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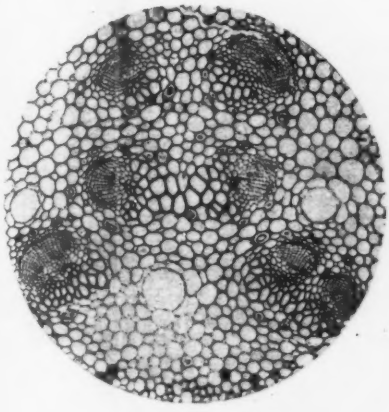

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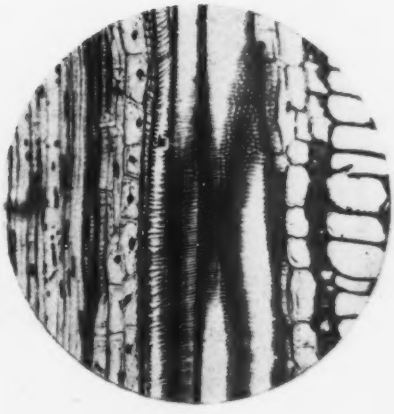

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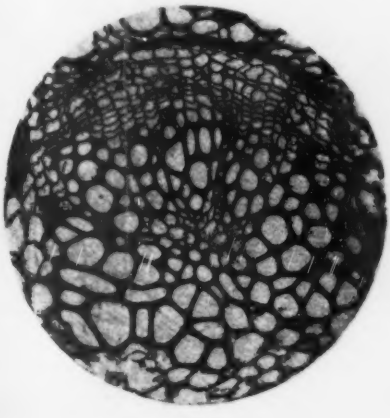

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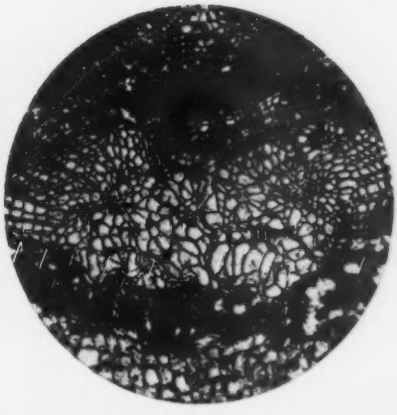

6

SINNOTT on FOLIAR BUNDLE

CONCURRENT OXIDATION AND REDUCTION BY ROOTS[1]

OSWALD SCHREINER AND M. X. SULLIVAN

EHRLICH (1), whose results have been verified by others, has shown that oxidation and reduction processes may exist side by side in the animal organism. According to him the functioning protoplasm can oxidize or reduce by means of its oxygen saturated or unsaturated compounds, respectively. Since the difference in metabolism between plants and animals is one of degree only, it is to be expected that the plant cell likewise should exhibit both oxidizing and reducing powers, as has been found to be the case (2). Oxidation has been more extensively studied on account of its more readily recognized significance in life functions. Reduction, however, is probably just as important as oxidation in the economy of the living cell, and is probably just as good an index of life activity. It is most likely that in the living cell oxidation and reduction alternate in quick succession, as DRECHSEL (3–5) has shown to be the case in certain oxidations outside the living body. It is probable that in this continual oxidation and reduction protoplasm suffers no change in its essential properties and thus preserves its identity.

The literature dealing with the oxidizing power of plant juices is voluminous. Within recent years our knowledge of processes going on within the plant has been greatly enlarged by the studies which have been made on the oxidizing enzymes. This work has been comprehensively summarized by CZAPEK (6), BACH (7), KASTLE (8), and CLARK (38).

The study of the oxidizing power of the plant roots in solution cultures, on the other hand, has received less attention. MOLISCH (9) appears to have been the first to demonstrate the oxidizing power of intact roots. He found that the root secretion was

[1] Contribution from the Laboratory of Soil Fertility Investigations. Published by permission of the Secretary of Agriculture.

capable of oxidizing various organic substances such as guaiacol, pyrogallol, and gallic acid. His work showed that there was considerable active secretion on the surface of growing roots and that this secretion had definite powers to effect changes in organic substances. CZAPEK (10) repeated some of the investigations made by MOLISCH and raised some doubt as to the correctness of MOLISCH'S conclusions. The fact that roots have oxidizing powers, as set forth by MOLISCH, has been well corroborated, however, by the investigations of RACIBORSKI (11), who used a number of reagents and widely different plants. He did not find a phanerogam, the roots of which did not have the property of extracellular oxidation. Great differences, however, existed between the oxidative powers of different plants.

Two classes of substances have been found useful in showing the oxidizing power of roots in solution culture. The first class comprises certain soluble chromogens which yield upon oxidation insoluble compounds mainly deposited upon the surface of the roots. The second class of chromogens consists of certain substances which give soluble coloring matter as the result of the oxidizing action of the roots, shown by the change from a colorless to a colored compound or by a change from one color to another which is distinctly different. Compounds belonging to the first class are alpha-naphthylamine, benzidine, vanillin, vanillic acid, and esculin. The second class of chromogens is in many respects more useful for oxidation studies, because the intensity of the color and hence the amount of oxidation can be quantitatively expressed. Among these substances are phenolphthalein, aloin, and leucorosolic acid.

When organic substances like alpha-naphthylamine and benzidine in solution of 10 p.p.m. and 5 p.p.m., respectively, are used, the colors due to oxidation are shown on the root. The most marked oxidation is shown by a narrow but very distinct band of color just back of the root cap. Then comes a practically colorless zone and then a broad colored zone, the color becoming less intense toward the upper part of the root. When a 0.04 per cent solution of aloin is used, a diffusion zone of color is at first formed close to the root, but in the course of a few hours the solution, as a

whole, becomes a cherry red, which varies in depth according to the amount of oxidation.

Reduction by roots has been studied but little. Reduction by the tissues of animals and by micro-organisms, on the other hand, has been extensively studied (**2**). The reagents used to indicate the reducing power of tissue are chromogens, which on reduction by abstraction of oxygen or by the addition of hydrogen yield a leuco-base, such as alizarin blue, indophenol blue, lacmus, methylene blue, indigo carmine, rosanilin, gentian violet; nitrates which are reduced to nitrites; sodium selenite and tellurite, which are reduced to metallic selenium and tellurium; sulphur, which is converted to hydrogen sulphide.

To show reduction we have tried various reagents and have found sodium selenite to be the best medium at our command. The selenite used was sodium selenite Merck and commercial sodium selenite Merck, the latter for the most part. Solutions of 0.25 per cent were first used. The solution reacted alkaline to litmus and phenolphthalein and was toxic to the seedling. When neutralized with hydrochloric acid, however, the toxicity of the selenite was greatly lessened. When seedlings were grown in the sodium selenite solution made neutral to phenolphthalein and of a strength of 0.125 to 0.25 per cent, the parenchyma cells of the ends of the root next to the cap were colored pink in a few hours by the deposit of selenium. The points of emergence of the secondary roots were often colored in the case of the older seedlings. After a lapse of several hours the whole root became somewhat pinkish. In solution of sodium selenite made $n/500$ acid by hydrochloric acid, the deposit of selenium at the tip of the root was very marked. In alkaline solution the reduction was very little. In short, reduction is more marked in slightly acid solutions. Oxidation, on the other hand, is stronger in slightly alkaline solutions.

As judged by the quickness with which the deposit of selenium is made on the root and the extent and intensity of the deposit, the reducing power increases from the time of germination to the sixth or eighth day and then decreases. It is still present in seedlings thirteen days old, the oldest seedling examined. The oxidative power of the wheat seedling, on the other hand, as judged by the

oxidation of aloin, is less in the young seedling and increases with age.

The relative oxidation was determined by placing the seedlings in culture bottles, 10 seedlings to a bottle, with the roots in the aloin solution made by dissolving 400 milligrams in one liter of pure distilled water. In 20 hours the depth of color produced by the red oxidation product was measured in the colorimeter. Taking the reading for the 12-day seedling as 100, the relative oxidation of the 8-day seedling was 81; of the 5-day seedling 48.

Oxidation of aloin by roots is greater in darkness than in light, the relation being in three separate tests with 4, 6, and 9-day seedlings, 100 in the darkness to 75, 70, and 71, respectively.

Nitrates and phosphates increase the oxidizing power of the wheat roots, while potassium salts, especially potassium iodide, decrease it.

TABLE I

EFFECT OF SALTS ON OXIDATION OF ALOIN BY ROOTS

			Relative oxidation
Control in pure distilled water			100
Sodium nitrate	50 p.p.m.	NH_3	135
Potassium sulphate	50 p.p.m.	K_2O	42
Acid calcium phosphate	50 p.p.m.	P_2O_5	117
Sodium nitrate Potassium sulphate Acid calcium phosphate	50 p.p.m.	NH_3, K_2O, P_2O_5	100
Potassium chloride	50 p.p.m.	KCl	38
Potassium iodide	50 p.p.m.	KI	20
Iodine	50 p.p.m.	I	16

In the experiment given in table I, the seedlings were started germinating January 4, and were put into the nutrient solutions January 10. On January 14 the aloin was placed in the solution, and on January 15 the oxidation readings were made.

The accelerating effect on oxidation of a solium nitrate solution containing the equivalent of 50 p.p.m. of NH_3 and the retarding effect of potassium salts equivalent to 50 p.p.m. K_2O is shown likewise in the case of plants grown in darkness. In this case the plants 6 days old were put into the salt solutions containing 0.04 per cent of aloin, and the experiment continued for 24 hours, when

the depth of the red oxidation product was measured in the colorimeter with the oxidation products of plants growing in carbon-treated water plus aloin as a control.

TABLE II

RELATIVE OXIDATION OF ALOIN BY ROOTS IN DARKNESS AND IN LIGHT

	In darkness	In light
Control	100	70
Sodium nitrate	150	105
Potassium sulphate	70	47
Potassium chloride	91	60
Potassium iodide	66	37

Since BIELECKI (**12**) has shown that nitrates of potassium, ammonium, and calcium added to a solution of peroxidase lead to its passing through a dialyzer in amounts proportionate to the amount of salt added, it may be that the nitrates increase the oxidizing activity of the wheat roots by allowing more of the oxidizing substance to pass into the medium. With alcoholic guaiac as an indicator, we have found a strong peroxidase reaction in the water in which the seedling roots had grown for 24 hours, and a stronger reaction in sodium nitrate solution in which plants have grown the same length of time. This peroxidase reaction does not occur if the culture water is boiled.

The observable action of salts on the reducing action is variable on account of lack of precision of method, though, as a rule, sodium nitrate equivalent to 50 p.p.m. NH_3 gives the quickest and heaviest deposit at the root tip, while potassium salts give the heaviest deposit on the rest of the root. The potassium salts which retard oxidation have little effect on reduction. Thus a potassium iodide solution containing 14.5 p.p.m. K_2O practically inhibited the oxidation of aloin by the roots of 5-day old wheat seedlings, while allowing good reduction of sodium selenite. It would seem, then, that reduction and oxidation may be independent of each other.

Attempts were made to show simultaneous oxidation and reduction by placing the seedlings with the roots in mixtures of sodium selenite and aloin, benzidine, and alpha-naphthylamine, respectively. In mixtures of sodium selenite and alpha-naphthylamine,

the two deposits of color on the roots were so nearly alike that it was difficult to tell whether selenium had been deposited or not in connection with oxynaphthylamine. In solution of benzidine, 5 p.p.m., the roots as a whole had a blue-black appearance, and a heavy ring appeared just back of the root cap. In the same strength of benzidine plus 0.25 per cent sodium selenite, $n/1000$ acid to phenolphthalein, the black oxidation ring at the root tip still appeared, but the roots, as a whole, were pink from the deposited selenium. In 0.04 per cent aloin and 0.15 per cent sodium selenite made $n/500$ acid, some oxidation of the aloin solution occurred and a good reduction of selenite. In aloin and sodium selenite $n/1000$ acid, there was strong oxidation and slight reduction.

The experiments show that it is possible to have oxidation and reduction by the same roots in the same solution. A slightly acid reaction is favorable to reduction, a slightly alkaline reaction favorable to oxidation. Between these acid and alkali limits both processes are demonstrable as occurring side by side.

It has long been supposed that oxidation by the plant roots and plant extracts is due to the presence of oxidizing enzymes, such as the oxidase, peroxidase, and the related catalase. A good review of the literature on cellular oxidation with consideration of the relationship between the enzymes may be found in works of BACH (**7**) and KASTLE (**8**).

According to BACH, the oxidase is a mixture of peroxidase and a peroxide-forming substance. The enzymes taking part in cellular oxidation are according to him oxygenase, peroxidase, and catalase. He explains their relationship as follows: (1) In order to have at its disposition a continued source of active oxygen, the living cell produces oxygenases or bodies capable of fixing atmospheric oxygen with the intermediary formation of peroxides; (2) the peroxides thus formed are activated by the peroxidase in the way that hydrogen peroxide is activated by ferrous sulphate; the system peroxidase-peroxide effects the oxidation of substances serving as aliments to the cell, substances which are oxidized with difficulty; (3) in cases which are particularly favorable to the formation of peroxide, excess of which might be injurious to the

cell, the cell generates a third ferment, catalase, which decomposes the peroxide with the liberation of molecular oxygen.

According to MOORE and WHITLEY (**13**), there is little evidence of the existence of BACH's oxygenase. These workers believe that all juices showing oxidizing properties possess one type of ferment which, since it acts only in the presence of either naturally occurring or artificial peroxide, may be styled a peroxidase. According to them there is no proof of the existence of any other type of enzyme engaged in oxidation processes.

In regard to cellular oxidation, it must be said that nothing absolutely certain is known regarding the composition or nature of the oxidizing substances in plants and the chemistry of the oxidizing bodies is uncertain. Apart from their destruction by heat and by poisons, little is known concerning their enzymotic nature. They do not seem to act as oxygen carriers in the sense of being able to transfer large amounts of oxygen from the air to the oxidizable substance, since the amount of oxidation is increased only slightly by an increase in the amount of oxygen present. Thus the relative oxidation by the roots of plants growing 4 hours in an atmosphere of pure oxygen and of air, respectively, was 100 and 80. The relative oxidation by plants in air and in a partial vacuum of a pressure of 23 mm. of mercury for 4 hours was 100 and 66; growing 19 hours in a partial vacuum, 100 and 74, respectively. In the partial vacuum the plant must oxidize the aloin by means of its intramolecular oxygen. In an atmosphere of carbon dioxide, oxidation was begun early, but this then stopped, and in 16 hours was a mere trace compared to the oxidation by plants growing in aloin solutions in air. Oxygen is necessary for plant oxidation, but a great increase in the amount of oxygen does not greatly increase the oxidation by plants.

Many, if not all, of the oxidations produced by the so-called enzymes can be brought about by non-enzymotic bodies, both organic and inorganic, as first shown by SCHÖNBEIN (**14**). Organic bodies like benzaldehyde, benzoyl peroxide, succinyl peroxide, pyrogallic acid, and quinone behave like an oxidase, as do peroxides and other salts of inorganic bases such as iron, lead, manganese, etc.

SPITZER (**15**) attributes the oxidizing power of animal tissue to the nucleoproteid they contain, the oxidizing power of the nucleoproteid being due to the combined iron they contain. In the absence of sufficient oxygen the same nucleoproteid acts as a reducing agent. BERTRAND (**16, 17**) showed that the oxidizing power of laccase from *Rhus vernicifera* is associated with the presence of manganese, and that laccase of alfalfa, which is poor in manganese, is inactive toward hydroquinone (**18**). The mixture of a trace of manganese salt and alfalfa laccase had strong oxygen-carrying power where either constituent alone had very little. Other metals such as iron, aluminum, cerium, zinc, copper, calcium, magnesium, and potassium did not increase the oxidizing power of laccase. BERTRAND showed that manganese salts which are easily hydrolyzable are most efficient oxygen carriers. He considered the active oxidase as special combinations of manganese and an acid radical, the latter probably of a proteid nature and partaking of the properties of a ferment. The manganese would be the really active element of the oxidase, while the acid radical would give the ferment the other properties such as solubility and sensitiveness to heat.

According to REY-PAILHADE (**19**), the reducing ferment which he found in plants, and which he has described under the name "philothion," possesses the properties of the acid albuminoid radical of the oxidases.

In connection with BERTRAND'S conception of the action of manganese and our study of the oxidation action of wheat roots, it is interesting to note that manganese has been found by MAUMENÉ (**20**) in many plants, among them wheat, as a salt of an organic acid. PICHARD (**21**) and GÖSSL (**22**) found manganese widespread in plants and animals. On the other hand, VADAM (**23**) found no manganese in the oxidase of hellebore, but did find iron; SARTHOU (**24**) found only calcium, iron, and sodium in the oxidase of *Schinus molle;* while DE STOECKLIN (**25**) could not find manganese in the ash of the oxidase from horseradish. BACH (**26**) believes he has obtained from molds an active oxidase which is entirely free from iron or manganese. VAN DER HAAR (**27**), however, doubts the validity of BACH'S conclusion as regards the absence of manganese. EULER and BOLIN (**28**) found that laccase from

alfalfa previously studied by BERTRAND consisted of the neutral salts, mainly calcium, of certain polybasic organic acids, among which glycollic, mesoxalic, citric, malic, and probably glyoxylic acids have been determined.

Numerous inorganic compounds will change tincture of guaiac blue. Among these SCHÖNBEIN (**29**) mentions the oxides of the noble metals, the so-called superoxides, saltpeter, chromic acid, permanganic acid, etc., lead peroxide, bromine, chlorine, etc. ALSBERG (**30**) has shown that many salts have the power to change guaiac to a blue oxidation product either directly or with the addition of hydrogen peroxide. MARTINAND (**31**) finds that oxides of alkalies and alkaline earths which can form peroxides and percarbonates fix oxygen of the air in an active form, and form bodies which give reactions like organic oxidases. Salts of the oxides of metals possessing several degrees of oxidation give the oxidase reaction in their maximum oxidation. The oxidation was retarded by certain salts and especially by traces of sulphuric acid. WOLFF (**32**) found that colloidal ferrocyanide of iron exerted in certain oxidations a catalytic effect similar to that of natural peroxidases. According to WOLFF and DE STOECKLIN (**33**), ferrocyanides and sulphocyanates of iron can produce oxidations which can be effected by natural peroxidases, each producing specific oxidations not characteristic of the other. DE STOECKLIN (**34**) later found that tannate of iron in the presence of hydrogen peroxide can bring about oxidation of such compounds as generally resist the action of any natural peroxidases now known. Among the substances were phenols, cresol, thymol, anisol, carvacrol, guaicol, pyrogallol, eugenol, isoeugenol, and tyrosine.

In work with aloin, we found that a solution of ferric chloride containing 3 p.p.m. Fe gave good oxidation of aloin. Ferrous chloride, even in solutions containing 25 p.p.m. Fe, did not oxidize aloin without the addition of hydrogen peroxide. With the addition of hydrogen peroxide, 1 p.p.m. Fe as $FeSO_4$ strongly oxidized the aloin. Other salts which have a direct oxidizing action on aloin are manganese dioxide, calcium oxide and carbonate, and magnesium oxide. Aluminum sulphate and chloride in 5 p.p.m. solution oxidized the aloin with the addition of hydrogen per-

oxide. Sodium and potassium hydrate oxidized the aloin slowly. Copper sulphate plus sodium chloride oxidized aloin solutions immediately. On the organic side, benzaldehyde, quinone, piperidine, atropine, etc., oxidize aloin solutions readily.

From what has been said, it can be seen that there is a strong similarity between the oxidizing action of wheat roots and catalyzers like inorganic salts and benzaldehyde and quinone. Probably the similarity is one of analogy only, the methods of oxidations being but different modes of oxygen transference to easily oxidizable bodies.

KASTLE and LOEVENHART (**35**) concluded that the so-called oxidizing ferment of the potato is not a true enzyme, but is an organic peroxide. They believe that the oxidation phenomena occurring in plants, and probably also in animals, can be satisfactorily explained upon the supposition that the readily autoxidizable substances which they contain are oxidized to the peroxide condition by molecular oxygen, and that the peroxides thus formed in turn give up part of their oxygen to other less oxidizable substances present in the cell. In other words, the process of rendering oxygen active by the living cell is probably brought about in essentially the same way that this is accomplished by phosphorus, benzaldehyde, and other oxygen carriers.

In regard to reduction by the living cell likewise, uncertainty exists as to whether it is brought about by a true enzyme or by non-enzymotic bodies. HEFFTER (**36**) has given this question much attention and has come to the conclusion that the reducing activities of organisms are not due to enzymes. As in the case of oxidation, reduction processes comparable to those of the living root may be brought about by purely chemical means, as we have previously shown (**2**).

As regards oxidation and reduction, it may be said that oxidative bodies may be extracted from the plant roots by suitable means. No body which would reduce sodium selenite in the cold could be extracted, however, although the water extracts of the seedlings reduce the selenite on heating. Thus it seems that the reduction of the selenite by the wheat roots is due to the metabolic

activities of the roots *per se*, and is probably due to the presence of some unsaturated compounds comparable to unsaturated fatty acids, dextrose, etc., which are readily oxidized in contact with air, or to substances like organic hydroxyacids and their salts which possess a slight reducing action.

In regard to the significance of the oxidation and reduction in roots, we may say that whatever increases the development of the plant increases oxidation by the roots, and contrariwise, whatever decreases oxidation by the roots decreases the growth of the plant. In short, oxidation is closely connected with the metabolic activities of the roots. It has been shown (**37**) that in extracts from productive soils oxidation by roots was strong, and in extracts of certain poor soils the oxidation was little, so that from a soil-fertility standpoint oxidation by roots has considerable interest. Oxidation is due undoubtedly to bodies capable of fixing atmospheric oxygen in an active form, perhaps as peroxides, which secondarily oxidize bodies by the transfer of active oxygen to them. Reduction seems to be connected with the inner metabolism of the plant, and is probably brought about by non-enzymotic compounds analogous to the organic hydroxyacids and their salts, which have a reducing action easily demonstrable by their changing of ferric iron to ferrous iron, or to compounds unsaturated in respect to oxygen, which by their avidity for oxygen reduce the oxygen-containing compounds they come in contact with. Oxidation processes are weak in the young seedling, but increase in strength as the seedling grows. Reduction processes, on the other hand, are predominant in the early stages of the seedling's growth, but are less manifest as the seedling develops and oxidation becomes predominant. In certain stages the two processes occur together and can be made manifest either independently or concurrently. Reduction seems to be mostly intracellular. Oxidation, on the other hand, is manifested strongly extracellularly, and seems to be by far the more prominent property of the plant root.

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THE DESERT LICHENS OF RENO, NEVADA

ALBERT W. C. T. HERRE

Reno lies at the eastern foot of the Sierra Nevada Mountains, some 15 miles from the Nevada-California boundary line, at an altitude of 4500 feet. It is built on a level tract known as the Truckee Meadows, through which flows the Truckee River. Mountains hem in this grassy valley on every side. Peavine Peak, lying northwest of the city, rises from Reno itself to a height of 8270 feet, while a little farther away and off to the southwest stands Mount Rose, with an altitude of 10,800 feet. To the north and east stretches a rolling plateau, a part of the Great Interior Basin, ridged by numerous parallel mountain ranges between which are a few streams during the rainy season and many sinks or drainage basins without outlet.

The average precipitation at Reno, as determined by observations at the University of Nevada over a period of 17 years, is 8.21 inches. A large part of this falls as snow during the winter months, or as early spring rains. The summer is hot and dry, very light showers occurring rarely. Late in the autumn light rains fall occasionally. During the entire year the diurnal changes of temperature, as in all desert regions, are very great. In winter the days are generally clear and sunny, the temperature dropping below freezing, or in some years even sometimes as low as -15° F. at night. Throughout the year strong drying winds from the west or north are very frequent, though these same west winds also bring what little rain there is. But usually they have lost their moisture in crossing the Sierras and are drying winds in Nevada. The spring is late and backward, killing frosts often occurring the last of May, and frost may occur in midsummer.

On the desert plateau proper there are no trees, except on the mountains above 6000 feet, the chief woody plants being sage brush, an *Ephedra* (Indian tea), *Grayia spinosa* (bud sage), *Emplectocladus Andersoni* (wild peach), *Purshia Kunzia* (bitter brush),

and perhaps a few other insignificant shrubs. On the mountain slopes and in the cañons above 6000 feet are found scattering clumps of *Pinus ponderosa* and *Juniperus occidentalis utahensis*, the latter sometimes forming real groves; while species of *Cercocarpus*, *Amelanchier*, and *Ceanothus* form shrubby patches 1–2 feet high, or become scraggly scattered bushes, or even trees 6–10 feet in height.

The region studied since October 1909 extends from the university campus in the city of Reno north and west a distance of 12 miles, and north and northeast about 6 miles. This district rises from 4500 feet to an altitude of over 8000 feet, the exposed rocks being mainly andesite and rhyolite.

At 5000 feet and upward lichens are, in general, exceedingly abundant on all outcropping ledges, stone pinnacles, or cliffs, as well as on the loose rocks which lie scattered about or piled in excessive quantities everywhere; but the few trees and the shrubs carry very few or no lichens. On the slopes of both Peavine and Mt. Rose I have vainly scrutinized the trunks and limbs of *Pinus ponderosa* for lichens. The trees were actually as bare as a new and freshly painted hitching post. The same condition is true of *Juniperus* out on the desert, 6 miles northeast of Reno, but 12 or 15 miles away, where there are belts of uncut juniper, *Letharia vulpina* is abundant upon it.

Before entering into a further discussion of the lichen flora of this region and the conditions which control it, let us examine the following list, which I am satisfied includes almost every species occurring below 8000 feet in this district. On Mount Rose a number of other forms appear near the summit, but the alpine lichens of that peak will be considered in a subsequent paper, as they bear no relation to the desert flora below.

1. VERRUCARIA FUSCELLA (Ach.) Turn.

2. VERRUCARIA STANFORDI Herre.—The discovery of this species here, described from the Santa Cruz Peninsula, California, greatly extends its range and is an interesting find. In addition to the type locality, I have this species from the Inner Coast Range, the Sierra Nevada Mountains along the California-Nevada boundary line above Verdi, and from the desert near Reno.

3. DERMATOCARPON MINIATUM (L.) Mann.

4. DERMATOCARPON MINIATUM COMPLICATUM (Sw.).

5. ENDOCARPON PUSILLUM Hedw.

6. **Endocarpon tortuosum** Herre, n. sp.—Thallus of small or irregular foliose squamules, tortuous and nodulose, often forming a rough, thick, and very irregular indeterminate crust; sometimes the squamules are densely compacted to form a thick, almost uniform torulose crust, while the squamules are stipitate, erect, and 7 mm. or more in height. When the squamules are scattered, their lobes are much dissected, and more or less complicate, recalling *E. pulvinatum*.

Color dull brown, verging from ashy brown to a dark, almost purplish brown; more or less greenish when wet; KOH−; $CaCl_2O_2$−.

Apothecia minute, immersed, the ostiolum sometimes visible with a strong lens; perithecium nearly colorless or very pale brownish; asci sub-cylindrical to saccate and top-shaped, $\frac{22.5-36}{85-135.5}\ \mu$, their contents copper red with I; paraphyses short, confluent, blue with I; spores 2, the upper one the larger, muriform-multilocular, the locules 4 across the spore, 10 or 12 in number the long way, at first colorless and mostly pale yellowish brown, but finally dark brown, $\frac{18-27}{45-61}\ \mu$; hymenial gonidia elliptical, measuring $\frac{2.75-3.3}{5.6-6.7}\ \mu$.

The plant is abundant 2 miles north of Reno, on shaded and relatively damp rock walls with a north or northeast exposure, at an altitude of 5000 feet. It is also frequent on cliffs in a cañon above Marmol, near the state boundary line, at an altitude of 6000 feet.

7. MICROTHELIA METZLERI Lahm.

8. LECIDEA ATROBRUNNEA (Ram.) Schaerer.—I have included under this name a large series of specimens which may represent two or three species. Some of the specimens bear a very close resemblance to *Lecidea fumosa* (Hoffm.) Ach., but do not agree in the apothecial structure. Other material is probably a new

species, but I place it here for lack of further material for comparison, and because as yet the abundant apothecia have not yielded me spores.

9. LECIDEA TESSELATA Floerke.

10. LECIDEA AURICULATA DIDUCENS Th. Fr.

11. LECIDEA SCOTOPHOLIS (Tuck.) Herre.—A doubt is cast upon this determination because of the small spores. A specimen from California, determined by TUCKERMAN, gives spores $\frac{3-5}{8-11}$ μ, while the Reno specimens have spores measuring but $\frac{3 \cdot 5-4}{5 \cdot 9-7 \cdot 5}$ μ.

12. **Lecidea truckeei** Herre, n. sp.—Thallus indeterminate, apparently of medium-sized, rigid, leafy, thickish scales which are densely crowded, ascendant or imbricate, with entire or crenate margin. On removing a single plant it is seen to be peltate, prolonged downward into a stout irregular stem, and with a broad top (4–10 mm. wide) of imbricate lobules, which form the scales of the thallus as seen from above; the lobules usually concave or undulate, less often revolute, their upper surface characteristically finely reticulate and wrinkled to form convex areolae; color dull chestnut brown or yellow brown; under side of the lobules black, the stems a dusky ashen; medulla bluish or purplish with I; thallus dusky olive with KOH+$CaCl_2O_2$.

Apothecia small, usually numerous, black; at first very small and flat, with a thin, rather entire and slightly lighter-colored margin; becoming convex as they get larger, and more or less excluding the margin; sometimes they are conglomerate or clustered and irregular; epithecium greenish black; hypothecium brown or brownish; paraphyses confluent or agglutinate, slender, threadlike; thecium greenish pale, turning blue with I; the ventricose fertile asci are rare; spores globose, 4.66 to 7 μ in diameter.

On rhyolite, 2 miles north of Reno, at an altitude of 5000 feet, forming conspicuous patches several inches broad. Though bearing a superficial resemblance to an unusually luxuriant form of *Lecidea atro-brunnea* or some forms of *Lecidea globifera*, it is markedly different in both thallus and spores.

13. BACIDIA TRISEPTA (Naeg.) A. Zahlbr. (?) or BACIDIA LECIDIOIDES (Anzi) (?).—Determination uncertain for lack of properly

determined material for comparison. Spores in my specimens measure $\frac{4 \cdot 5-5 \cdot 6}{11 \cdot 3-14 \cdot 8}$ μ.

14. RHIZOCARPON MONTAGNEI (Flot.) Koerber.

15. BIATORELLA REVERTENS (Tuck.) Herre.

16. ACAROSPORA RUFESCENS (Sm.) Th. Fr.

17. ACAROSPORA CERVINA (Pers.) Koerber.

18. ACAROSPORA SQUAMULOSA (Schrad.) Th. Fr.—Spores of Reno material are $\frac{2 \cdot 2-2 \cdot 33}{4-5}$ μ. This is too small for *squamulosa*, but I cannot place our plant elsewhere.

19. ACAROSPORA THAMNINA (Tuck.) Herre.—This is a peltate plant which I place here with doubt, having no material for comparison, but it agrees fairly well with the description.

20. ACAROSPORA PELTASTICA A. Zahlbr.—Occurring in small patches amid other lichens, and rather common on the rocky débris of the desert. Hitherto known only from the deserts of southeastern California.

21. ACAROSPORA BELLA (Nyl.) Herre.

22. ACAROSPORA CHLOROPHANA (Wahlb.) Mass.

23. GYROPHORA RETICULATA (Schaer.) Th. Fr.

24. GYROPHORA HYPERBOREA (Hoffm.) Ach.

25. GYROPHORA PHAEA (Tuck.) Herre.

26. GYROPHORA EROSA (Web.) Ach.—Usually dwarfed and non-typical.

27. THYREA PULVINATA (Schaer.) Mass.—In small holes or crevices on the south and southeast face of a rhyolite cliff.

28. PECCANIA ARIZONICA (Tuck.) Herre. *Omphalaria arizonica* Tuck. *in litt.* (1884?).—Thallus indeterminate, dull, black, minutely fruticulose, forming sub-crustaceous pulvinate nodules, which to the naked eye appear to be composed of almost microscopic uniform granules; branches numerous, irregular, more or less knobbed, their tips often enlarged and broken up into several blunt points. Apothecia not known to me. "Spores 8, sub-globose, 0.75 μ."

A few scanty specimens were found growing on the minute quantities of earth which collects in small shallow holes on the south a face of rhyolite cliff 2 miles north of Reno.

I have a specimen collected by C. G. PRINGLE in the Santa Rita Mountains, Arizona, in 1884, and another collected by Dr. W. G. FARLOW at El Paso, Texas, and both named by TUCKERMAN *in litt.* My material from Reno agrees with both of these specimens.

All three are sterile, but on the sheet to which the one from Arizona is fastened is written the spore measurements quoted by me above, presumably copied from TUCKERMAN's findings of other and fertile material.

29. HEPPIA GUEPINI (Delis.) Nyl.

30. LECANORA GIBBOSA (Ach.) Nyl.—Part of the specimens are not at all typical and probably represent a new variety.

31. LECANORA CALCAREA (L.) Sommerf.

32. LECANORA OLIVACEA (Bagl. & Car.) Steiner (?).—The spores of my material measure but $\frac{4.6}{8.1-9.3}$ μ, while in European material they measure $\frac{5-6}{10-14}$ μ; in other respects the plant seems to agree.

33. LECANORA SAXICOLA (Poll.) Ach.—Our Nevada material is excessively variable and some forms are brought under this species with great difficulty. A brown, white-pruinose form is very common and may represent TUCKERMAN's var. *versicolor*, or it may be new.

34. LECANORA sp.—This lichen belongs to the *saxicola* group, but I am unable to determine it more closely. Intermediate between *L. saxicola* and *L. thamnoplaca*, but quite distinct from either.

35. LECANORA THAMNOPLACA Tuck.—Very abundant on loose rocks and on cliffs.

36. LECANORA MELANOPHTHALMA (DC.) Jatta.

37. LECANORA RUBINA (Vill.) Ach.

38. LECANORA RUBINA HETEROMORPHA Ach.

39. CANDELARIELLA CERINELLA (Flk.) A. Zahlbr.

40. PARMELIA GLABRA Schaerer.

41. PARMELIA EXASPERATA (Ach.) Nyl.

42. PARMELIA CONSPERSA (Ehrh.) Ach.

43. PARMELIA (?).—Too fragmentary for determination. On cold, shaded, north slopes.

44. PARMELIA PUBESCENS (L.) Wainio.

45. LETHARIA VULPINA (L.) Wainio.

46. XANTHORIA POLYCARPUS (Ehrh.).

47. XANTHORIA LYCHNEUS LACINIOSA (Schaerer).—The specimens are sterile but well marked, and grow on the north slope of a rhyolite cliff.

48. BLASTENIA FERRUGINEA (Huds.) Arn.

49. CALOPLACA ELEGANS (Link.) Th. Fr.

50. CALOPLACA ELEGANS TRACHYPHYLLUM Tuck.

51. CALOPLACA MURORUM (Hoffm.) Th. Fr.

52. CALOPLACA CINNABARINA (Ach.) A. Zahlbr.

53. BUELLIA ALBO-ATRA (Hoffm.) Th. Fr. and var. SAXICOLA Fries.

54. BUELLIA TRIPHRAGMIA Nyl.

55. RINODINA THYSANOTA Tuck.

56. RINODINA OREINA (Ach.) Mass.

57. PHYSCIA PULVERULENTA (Hoffm.) Nyl.—Specimens scanty and sterile.

58. PHYSCIA STELLARIS (L.) Nyl.

59. PHYSCIA TRIBACIA (Ach.) Tuck.

It is doubtful whether one should include *Letharia vulpina* as really belonging to the desert flora. In the western Sierras it is a very abundant and conspicuous lichen, but seems hardly able to withstand the drying winds of high velocity so characteristic of the western Nevada region. On Peavine Peak, at an altitude of 7000 feet, I found two small sterile specimens growing on the butt of a scraggly *Cercocarpus*. But as already stated, where there are groves of juniper it occurs in abundance, probably because there it is sheltered from the high winds which prevent its development in more exposed situations.

Parmelia pubescens occurs at about 7500 feet on Peavine Peak, and also very sparingly on a cold north wall, where it is well sheltered from the sun, at an altitude of 5000 feet. But it is really a plant of the high Sierras and cannot be reckoned as a real factor in the desert lichen flora.

This leaves us with 57 species and subspecies which we may safely include in the flora of the desert about Reno. Of this num-

ber only three dwell on wood; *Buellia triphragmia* occurs sparingly on the trunks and limbs of sage brush, while *Xanthoria polycarpus* is rather common on the same habitat, usually near the base of the gnarled and twisted trunk, where it is well sheltered by the densely branching shrub above. *Candelariella cerinella* is best developed and most abundant on rocks, but likewise occurs on clumps of dead moss in the shadow about the base of decumbent sage brush trunks, and to some extent on the trunks themselves; but it is, properly speaking, a rock lichen.

Comparing our 55 saxicolous lichens with the 25 obtained near the Carnegie Desert Laboratory at Tucson, Arizona, we find 22 genera represented at Reno, while only 11 were collected at Tucson. Apparently but 9 species are identical in the two localities.

Three genera are especially well represented about Reno: *Lecanora* with 9 forms, *Acarospora* with 7, and *Lecidea* with 5, these three comprising over 38 per cent of the species of rock lichens of the region. If we include the highly successful *Caloplaca elegans*, we have 4 genera of the 22 which probably cover three-fourths of the rock surface devoted to lichens; while the addition of *Rinodina* and *Gyrophora* would give us at least nine-tenths of the individuals found on the desert rocks. The remaining genera are not only poor in number of species but are also poorly represented by numbers of individuals. As we pass from desert to alpine conditions, we find that *Gyrophora* becomes the dominant genus, followed by *Acarospora*, *Caloplaca*, and *Lecidea*.

The rainfall at Tucson is 13.53 inches, or 42.87 per cent greater than at Reno. Yet no species of *Lecidea* were collected at Tucson, while at Reno the genus is well represented, relatively speaking. This shows that their absence at Tucson is not due to dryness, but to other causes. It will be noted that the chief representative of the genus at Reno is the alpine or subalpine *Lecidea atrobrunnea*. In like manner we may account for the prominence of the *Lecanora rubina* group at Reno and its entire absence at Tucson by the higher altitude and prevailing low temperature for a large part of the year at Reno, these species of *Lecanora* being characteristically subalpine or alpine plants.

The coloring characteristic of the rock ledges of the desert and

cañon walls is often entirely due to lichens, and in a general way they form the only brilliant plant formations in a landscape notable for its subdued, pale, monotonous tones. Most conspicuous are *Acarospora chlorophana* and *Caloplaca elegans*, which form striking landmarks when covering great crags and rock walls. The next most conspicuous lichens are *Rinodina oreina* and *Lecanora rubina* and its allies, which often entirely cover immense bowlders and northerly sloping rock walls. In places *Gyrophora erosa* and *Gyrophora phaea* may cover the rocks to the exclusion of other forms, but their dull brown shades are not at all conspicuous. *Gyrophora reticulata* is sometimes the sole occupant of northwest exposures, when its black thallus becomes quite noticeable.

Candelariella cerinella and *Acarospora bella* are perhaps the only others which would attract the attention of the casual observer, nearly all the others having a dull or somber brown or dusky hue which blends in with the general rock color.

The species of *Dermatocarpon* occur in crevices of rock walls, especially on northeastern and southeastern slopes, where they receive the maximum of protection from drying winds. The few small specimens of *Physcia* occur in the same localities, where they are very little or not at all exposed to direct sunlight. The remaining lichens, except where previously noted, occur indifferently on all sides of bowlders or rock ledges, the sunniest and most arid of all possible situations, where one would hardly believe a plant could exist, being occupied by *Gyrophora phaea* and *Acarospora thamnina*. The largest and finest specimens of *Gyrophora reticulata*, as well as the best specimens of *Lecanora rubina*, are on northern or northwesterly exposures; this I attribute to the fact that these slopes are much colder, being exposed to the direct winds from the snow fields of the Sierras, and are also often covered for weeks with great snow drifts.

With the exception of *Lecanora rubina* and its allies, few of the well exposed rock lichens could fairly be called foliose. The short-lobed species of *Gyrophora* hug the rocks as closely as possible, so that they are truly crustose except when in some sheltered crevice or more than ordinarily favorable position. The quite inconspicuous and sterile thallus of *Parmelia exasperata* and *Parmelia glabra*

is usually far more closely attached to the rocks than many of the species of *Lecidea* or *Acarospora*.

In FINK's study of the Tucson lichens, he speaks of the remarkable development of black lines or spots on the upper surface of every species having a light-colored thallus. I find practically nothing of the kind on the lighter-colored species at Reno, such as *Acarospora chlorophana*, *Acarospora thamnina*, *Lecanora gibbosa*, *Buellia albo-atra*, or *Physcia stellaris*, though all but the last named occur frequently where they are exposed to the full glare of a brilliant sun set in a cloudless sky for ten or twelve hours daily during most of the year. I do find some such dark spots on *Rinodina oreina*, but not any more, if as many, as occur on it in regions elsewhere with a rainfall of 20 inches. *Acarospora thamnina* and other sterile light-colored lichens are often blotched with dark spots simulating apothecia, but a section shows them to be parasitic fungi.

Certain species of *Acarospora* and *Lecidea* are noticeable for the thickness and comparative luxuriance of their thallus, and for their sterility, certain forms which I can identify with difficulty or not all at being persistently sterile though of a rank vegetative growth.

In his study of the Tucson desert lichen flora, FINK takes up the question of the amount of moisture desert rock lichens may obtain from the upward passage of water through the rocks. Geologists and botanists here in Nevada do not believe that lichens obtain any appreciable amount of water from the desert rocks upon which they grow by the upward passage of moisture through the rocks. All observation goes to substantiate FINK's statement "that lichens absorb at least a large proportion of the moisture needed directly from water vapor of the atmosphere and from water falling upon them." Incomplete experiments by me show that lichens not only retain a considerable amount of moisture within their thalli even in the driest times, but that they imbibe moisture from rain with very great rapidity and in great quantity, relatively speaking.

But that the desert lichens of this region do not depend upon water obtained by capillarity is readily understood when one exam-

ines the vast numbers of loose rocks lying upon air-dry soil, yet thickly covered with lichens. This fact is impressed still more strongly when one sees the luxuriant growth of certain lichens upon the loose slabs and fragments forming the talus about cliffs; often they are some feet above the soil or outcropping rock, and lie in such a position that the hot desert air blows all about them, under as well as over; yet the lichens seem to thrive as well on these fragments as on the cliff itself. In these cases it seems plain that the only source of water for the lichens thereon is from direct precipitation and from the atmosphere.

During the summer months it is highly probable that a careful study would show that the great diurnal drop in temperature which comes in all arid regions with the advent of darkness is likewise accompanied by a deposition of moisture upon, or at least an increase in water content of, the desert lichens.

When one considers that the temperature drops 30° to 35° F. every night during the summer months, it is apparent that without any increase in the actual amount of water present there is a great increase in the percentage of moisture, and it is believed by some of us that the lichens are able to take advantage of this relative increase and absorb enough moisture to maintain their vitality during the long, hot, dry season.

Though the winters here are characterized by a comparatively low temperature, they are yet open and sunny, so that during the daylight hours they are usually quite mild. This mildness and the fact that the winter is the season when most moisture is available, especially that from melting snows, cause the lichens to have their period of most active growth during the months from November to June. Except under unusually favorable conditions, it is not likely that the Nevada desert lichens are more than able barely to keep alive during the remainder of the year.

That desert conditions are, in the main, unfavorable to the growth of lichens as a whole is shown by the limited number of genera and species represented, while a considerable number of those found are able to maintain themselves only in the most favorable spots, such as under overhanging rocks on the north side of cliffs, or deep within crevices. But that some species are per-

fectly at home in the midst of the most adverse desert conditions of excessive light and dryness is shown by the fact that almost everywhere the rocks are just as thickly covered with lichens as in other regions of greater humidity and less sunshine. The desert does not lack in number of individuals, but in number of species of lichens able to adapt themselves to its conditions.

OAKLAND, CALIFORNIA

BRIEFER ARTICLES

A CONVENIENT MICROTOME KNIFE

(WITH FIVE FIGURES)

Few people know how to sharpen a microtome knife, and those who have acquired the art usually have something else to do. The professional knife sharpener will grind out the nicks but will not produce the edge needed for paraffin cutting, and it is useless to explain what one wants, because he sharpens operating knives for the best surgeons in the city, and what is good enough for them is good enough for a botanist.

Several years ago we suggested that if manufacturers would make a clamp to hold the blade of the Gillette safety razor, its hard, even edge would doubtless be satisfactory for microtome sections, and the blades being rather cheap, it would not be necessary to sharpen them when they became dull. Numerous attempts to make a holder proved more or less unsatisfactory. Some of these discarded holders were very much like one described in the current number of *Annals of Botany*.[1] The objection to this knife is that the blade, being held between two flat pieces of steel, is not absolutely rigid. Further, such a holder clamped directly into the microtome does not place the edge of the blade in the most favorable position for cutting.

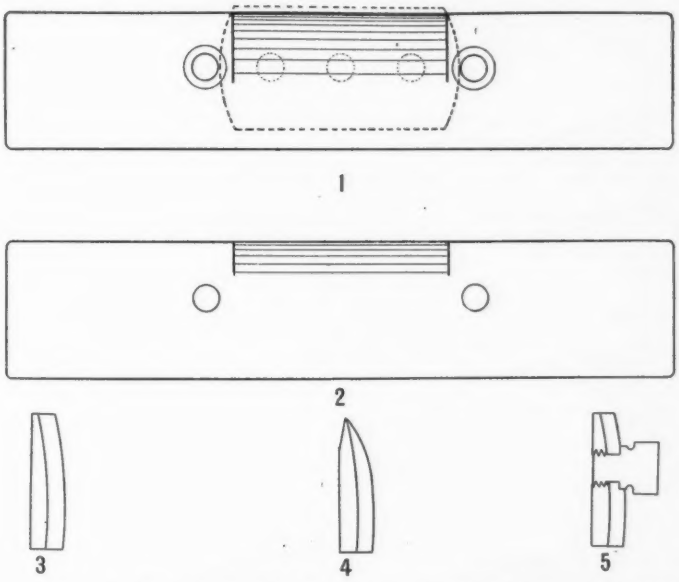
After our own efforts had failed to secure the results which we believed the cutting edge of the safety razor should produce, we prevailed upon a well-known optical company to make a sample holder, and this was fairly satisfactory, but the price ($13) seemed practically prohibitive.

We then explained to a skilled mechanic[2] just what we wanted, and he made a holder which is quite satisfactory and costs only $3. It is made of brass and can be used in either rotary or sliding microtomes; the essential features can be seen in figs. 1–5. About 13 or 14 cm. is a convenient length for the holder. The sectional views show that the two pieces are not straight, but are slightly curved, a feature which insures

[1] BENTLEY, B. H., An arrangement for using the blades of safety razors in the microtome. Annals of Botany **25**:273–275. 1911.

[2] A. W. STRICKLER, 1311 E. 57th Street, Chicago, Ill.

great rigidity, and also allows the paraffin block to clear readily. The curve is easily secured by cutting the two parts of the holder from two large brass tubes, one being about 12.5 cm. in diameter, and the other fitting as closely within it as an ocular in a microscope. The thickness should be about 3 mm.



FIGS. 1–5.—Fig. 1, back view; fig. 2, front view (toward the paraffin block); fig. 3, end view; fig. 4, sectional view at the middle; fig. 5, sectional view at the screws, which are represented by the double circles in fig. 1, and by the single circles in fig. 2.

It is neither necessary nor desirable to have pins fitting the three holes in the knife, since they add nothing to the rigidity and even interfere with the insertion and adjustment of the blade. The binding screws should be as close as possible to the blade, and not at the ends of the holder, as shown in the form described in the *Annals of Botany*.

With the Gillette blade in this holder, we have cut smooth sections 2 and 3 μ in thickness, and have also cut large sections 2 cm. in diameter and 15 μ in thickness, even such refractory objects as the strobili of *Isoetes* and *Selaginella* cutting as smoothly as with a first-class microtome knife in perfect condition.

In general, the blade should project only far enough to allow the paraffin block to clear. Naturally, the blade might project a little farther in case of thin delicate sections than with thick hard ones, but a little experience will accustom one to the use of such a knife, and the luxury of having at all times a fresh keen cutting edge will be appreciated by all who have known the drudgery demanded by the microtome knives in general use.—CHARLES J. CHAMBERLAIN, *The University of Chicago.*

ADDITIONS TO THE GRASSES OF CUBA

Since the publication of the *Catalogue of the grasses of Cuba*,[3] several additional species of grasses have been contributed to the National Herbarium by Brother LEÓN of the Colegio de la Salle, Habana. The following is a list of these:

MANISURIS EXALTATA (L. f.) Kuntze, Rev. Gen. Pl. **2**:779. 1891.

Stegosia exaltata Nash, N. Amer. Fl. **17**:84. 1909.

This species is retained provisionally in *Manisuris* until the genera of Andropogoneae are more carefully examined.

Sancti Spiritus, *León* 847.

ANDROPOGON SQUARROSUS L. f. Suppl. 433. 1781.

Habana, *León* 1581. Introduced.

ANDROPOGON CARICOSUS L. Sp. Pl. ed. 2. **2**:1480. 1763.

Guanabacoa, *León* 2013. Introduced.

Sorghastrum agrostoides (Speg.).

Andropogon agrostoides Speg. Pl. Nov. Nonnul. Amer. Austr. Dec. **2**:27. 1883.

Sancti Spiritus, *León* 895.

PASPALUM BLEPHAROPHYLLUM Nash, in Small Fl. Southeast. U.S. 71. 1903.

Marianao, *León*, 779.

PASPALUM HELLERI Nash, Bull. Torrey Club **30**:376. 1903.

Santiago de Cuba, *León* 951.

PASPALUM MONOSTACHYUM (H. B. K.) Vasey, in Chapm. Fl. South. U.S. ed. 2. 665. 1889.

Zaza de Tunas, Santa Clara, *León* 947. The spikelets are smaller than in the typical form.

[3] HITCHCOCK, A. S., Contr. Nat. Herb. **12**:183–258. 1909.

Paspalum Leoninum Chase, sp. nov.—A low tufted perennial, with narrow leaves mostly crowded at the base, slender nearly naked culms and solitary usually purplish racemes. Culms 15–35 cm. high, very slender, wiry, compressed, ascending or spreading and more or less sinuous, glabrous, the nodes ascending-pubescent; lower sheaths overlapping and keeled, glabrous or sparsely pubescent on the scarious margin and with a few stiff hairs on the auricles, usually but a single leaf about midway on the culm, the sheath with a few scattered long hairs or glabrous; ligule membranaceous, about 0.5 mm. long; blades flat or somewhat involute from a folded base narrower than the summit of the sheath, 3–7 cm. long, 1–2 mm. wide, more or less curled, glabrous on both surfaces or minutely puberulent on the upper, a few stiff hairs on the margin and rarely on the upper surface, the blade of the uppermost leaf reduced to a mere tip; raceme 2–3.5 cm. long, slightly curved, a few long hairs at the base; spikelets solitary, on very short, flattened, scabrous pedicels, closely imbricated, almost concavo-convex, 1.3–1.5 mm. long, about 0.7 mm. wide, oval, glabrous; second glume 3-nerved, the sterile lemma with a nerve near either margin, the midnerve suppressed or apparent only at the summit; fruit nearly as large as the spikelet.

Type U.S. National Herbarium no. 618,754; collected August 30, 1909, on "Obispo hill, near Sancti Spiritus," by Brother *León* (no. 950).

This species is most nearly related to *Paspalum rupestre* Trin., from single-spiked specimens of which it may be distinguished by the more delicate culms and the more closely imbricated, glabrous spikelets, the second glume with the midnerve suppressed.

Paspalum Leoninum is named in honor of Brother León, of the Colegio de la Salle, Vedado, Habana, whose collections have added greatly to our knowledge of the grasses of Cuba.

A second collection of this species was made on the Jata Hills, Guanabacoa, September 12, 1909, *León* 949.

Cenchrus myosuroides H. B. K. Nov. Gen. & Sp. **1**:115. 1816.

Santiago de Cuba, *León* 835.

Gouinia polygama Fourn. Mex. Pl. **2**:103. 1886.

Cojimar, *León* 2014.

Arundo Donax L. Sp. Pl. 81. 1753.

Marianao, *León* 1523. Escaped from cultivation.

Lolium temulentum arvense (With.) Bab. Man. Brit. Bot. 377. 1843.

Habana, *León* 1583. Introduced.

It may be well to record here certain changes in the names of a few species of *Panicum* listed in the *Catalogue*, as shown by the recent revision of this group.[4]

Panicum aquaticum Poir. This is a synonym of *P. dichotomiflorum* Michx. The Cuban species is *P. elephantipes* Nees.

Panicum compactum Sw. = **Lasiacis compacta** (Sw.).

Panicum distantiflorum Rich. To this species was referred *Panicum utowanaeum* Scribn. (*P. Sintenisii* Nash), which proves to be a distinct species. It is represented by two specimens from Triscornia, near Habana, *Hitchcock* 141 and *Tracy* 9089.

Panicum divaricatum L. = LASIACIS DIVARICATA (L.) Hitchc.

Panicum Grisebachii Nash = **Lasiacis Grisebachii** (Nash).

Panicum hirtivaginum Hitchc. This species appears to be the same as *P. Ghiesbreghtii* Fourn. of Mexico.

Panicum laxum Sw. To this was referred *P. polygonatum* Schrad. which, however, proves to be distinct, and is easily recognized by its pubescent nodes, and by the lack of the swollen sterile palea which characterizes *P. laxum* and *P. pilosum*.

Panicum numidianum Lam. This species appears to be confined to the North African area and, though not well known, is sufficiently distinct from *P. barbinode* Trin. of Cuba and tropical America.

Panicum Rugellii Griseb. = **Lasiacis Rugellii** (Griseb.).

Panicum Sellovii Nees. An earlier name is *P. millegrana* Poir.

Panicum Sloanei Griseb. = **Lasiacis Sloanei** (Griseb.).

Panicum Swartzianum Hitchc. = **Lasiacis Swartziana** (Hitchc.).

To these may be added the following two corrections in genera allied to *Panicum*:

Mesosetum rottboellioides (H. B. K.) Hitchc. A comparison of the type specimens shows that the Cuban species is **Mesosetum loliiforme** (Hochst.) Chase (*Panicum loliiforme* Hochst.[5]).

Hymenachne auriculata (Willd.) Chase. The specimen mentioned, Wright 3863 in part, is *H. patula* Fourn.[6]—A. S. HITCHCOCK, *U.S. Department of Agriculture, Washington, D.C.*

[4] HITCHCOCK and CHASE, Contr. Nat. Herb. **15**:1–396. 1910.

[5] Steud. Syn. Pl. Glum. **1**:56. 1854.

[6] Mex. Pl. **2**:37. 1886.

CURRENT LITERATURE

BOOK REVIEWS

Fertilization

The problem of fertilization has been studied chiefly by morphologists, who have limited themselves rather strictly to the structures concerned, and consequently a book by a prominent investigator,[1] dealing primarily with the physiological aspects of the case, cannot fail to be interesting and helpful. While the physiological standpoint is everywhere in evidence, the morphology is fairly presented, and the general conclusions, based upon both physiology and morphology, are suggestive.

Fortunately, NĚMEC does not confine himself to fertilization as usually defined, but devotes a large share of his attention to nuclear and cell phenomena in vegetative tissues, where he believes such phenomena may be of value in interpreting the process of fertilization. In this connection he discusses multinucleate cells, fusions in such cells, karyomere-formation, and the effect of chloral hydrate and chloroform upon cells and nuclei. Some attention is given to the behavior of nuclei in wound tissue, and to the influence of plasmolysis upon nuclear and cell division. Interesting chapters deal with the development of the chromosome and reconstruction of the nucleus, and with the influence of external factors upon the form of the chromosome. There is also a chapter upon the microchemistry of the nucleus and mitotic figure. These are the principal features of the first, or special part of the book.

The second, or general part, may seem to cover the whole field of cytology, but a glance at the chapter headings shows that the wide range of matter is pertinent and emphasizes the breadth of the subject. The headings are: the persistence and individuality of the chromosome; the relation between the size of nuclei and cells; the position of the nucleus; vegetative and sexual nuclear fusions; the reduction of chromosomes; the significance of chromosome numbers in alternation of generations; the nucleus as the bearer of hereditary characters; the nature of fertilization; and the individuality of the cell in the tissue.

Space would hardly permit a discussion of all these fundamental problems, but a mere statement of NĚMEC's position may be of interest. He believes that the hypothesis of the individuality of the chromosome offers the best explanation of the known facts, and suggests that the individuality may yet be demonstrated, perhaps by microchemical methods. Further, the number

[1] NĚMEC, B., Das Problem der Befruchtungsvorgänge und andere cytologische Fragen. 8vo. pp. 532. *pls.* 5. *figs.* 119. Berlin: Gebrüder Borntraeger. 1910. *M* 20.

of chromosomes (*ceteris paribus*) regulates the size of the nucleus and furnishes the best evidence for the individuality hypothesis. Nuclear fusion and reduction of chromosomes are regarded as important autoregulative processes which take place only under definite internal and external conditions. Although admitting that the nucleus is of great importance in transmitting hereditary characters, he does not believe that it is the sole bearer of such characters, but that this function is performed by the nucleus and cytoplasm together.

It is fortunate that physiological methods are being brought to bear upon morphological and cytological problems. The morphologist, with his limited knowledge of physiology, is necessarily one-sided in his methods and conclusions; the physiologist, with a correspondingly limited knowledge of structures and development, brings other methods and other viewpoints to the solution of the problem; and thus each corrects and stimulates the other, so that problems which either could not solve alone become possible. The strict morphologist and cytologist will find in this book much with which he cannot agree, but nevertheless he will be compelled to recognize it as a valuable contribution to the subject.—CHARLES J. CHAMBERLAIN.

Response to light

MAST[2] has written a thoroughly interesting book on the response of organisms to light. It consists of four parts: "Introduction and historical review" (pp. 1–57); "Experimental observations and discussions bearing on the question as to how organisms (especially those without eyes) bend or turn and move toward or from a source of stimulation" (pp. 59–235); "General considerations of reactions to light" (pp. 236–298); and "Reaction in light of different wave-lengths or colors" (pp. 304–393). A bibliography of 14 pages cites the more important literature on the subject, and frequent and excellent summaries make the main conclusions readily accessible.

The work brings together our knowledge of the response to light in plants, motile and sessile, and in animals, protozoa and metazoa. It is a consideration of response to light from the evolutionary point of view. MAST says, "the generality of the treatment of the subject of actions in organisms, including plants as well as animals, it is hoped will make the work of value to all students of nature, especially to those interested in comparative psychology, zoology, botany, and physiology."

Much of the second part is a statement of the author's own research. His work was mainly with animals, yet he has made contributions to plant response. He takes up the long discussed question as to whether directive response to light is determined by the direction of the rays or by the difference of intensity on different flanks. He uses the maize seedling with apparatus that apparently answers all the objections to former methods. His results

[2] MAST, S. O., Light and the behavior of organisms. 8vo. pp. xi+410. *figs.* 35. New York and London: John Wiley and Sons. 1911.

seem to prove conclusively that OLTMANN's intensity theory is right, and that SACHS's ray direction theory is wrong. This chapter alone is no mean contribution.

At many points the author opposes LOEB's conception of response. This is done with vigor, if not with feeling. Quotations from the summary of part II put forth some of the questions in dispute: "There is no conclusive evidence, except perhaps in animals with image-forming eyes, showing that light acts continuously as a directive stimulus, that symmetrically located sides are continuously stimulated, equally when the light intensity on them is equal, unequally when it is not, and this regulates orientation by regulating the rate of motion of the locomotor apparatus on the two sides as is demanded by the theories of DECANDOLLE, LOEB, VERWORN, DAVENPORT, and RÁDL."

"There is no conclusive evidence showing that orientation in light is ever due to tropic reaction in any organisms, if the definitions of tropisms given by LOEB, VERWORN, or RÁDL are used as criteria."

"The idea of reactions to change of intensity, however, is not original with LOEB, as is sometimes assumed. The explanations of reactions to light given by ENGELMANN, BERT, GARBER, LUBBOCK, ROMANES, DARWIN, and others, all of whom preceded LOEB, were largely founded on this idea."

The work in the main agrees with JENNINGS' results and conclusions from his extensive studies. It supports his views on trial reactions, motor reflex, physiological state, and the adaptive character of reactions.—WILLIAM CROCKER.

MINOR NOTICES

Trees and shrubs of Southern California.—Abrams[3] has published the results of an extended field and herbarium study of the trees and shrubs of southern California. The territory involves about 40,000 square miles, or approximately one-fourth the area of the entire state. The author gives a careful consideration of the general physiographic and phytogeographic features of the southern portion of the state, and divides this area into three floral regions: (1) *the coastal slope*, (2) *the mountain*, and (3) *the desert*. The species of the first region are said to be "principally of Californian origin," of the second "boreal or of boreal ancestry," and of the third "endemic or migrants from the Great Basin, Sonora, or Lower California." Each floral region is divided into zones, in accordance with MERRIAM's outline, and these again are defined and characterized in more or less detail.

The body of the work bears the modest title of "Annotated catalogue of the southern California trees and shrubs." It is indeed far more that the term "catalogue" implies, since the text is provided with succinct keys to genera and species in most of the larger groups; there is also a limited amount of synonomy, copious notes, and ample citation of exsiccatae. New species

[3] ABRAMS, LEROY, A phytogeographic and taxonomic study of the southern California trees and shrubs. Bull. N.Y. Bot. Gard. **6**:300–485. *pls. 10.* 1910.

are recorded in *Lupinus* (*L. Brittoni*), *Amorpha* (*A. occidentalis*), *Ceanothus* (*C. austro-montanus*), and *Malacothamnus* (*M. Nuttallii*); and several new combinations are made. The work includes 375 recognized species, representing approximately 150 genera, distributed in 57 families. Whether or not we agree with the limitation of groups and the nomenclature in all cases is a matter of minor significance. It is a pleasure to state that the author has given us a work which will serve as an exceedingly helpful guide in studying the woody plants of southern California.—J. M. GREENMAN.

North American Flora.[4]—Volume III, part 1, contains a treatment of the Nectriaceae and Hypocreaceae by F. J. SEAVER, the Chaetomiaceae by H. L. PALLISER, and the Fimetariaceae by D. GRIFFITHS and F. J. SEAVER. These four families are represented by 242 species which are referred to 45 genera. One new species is described in *Scoleonectria* (*S. tetraspora*), found growing on trunks of cacao in Jamaica, and four new species from eastern and central United States are added to *Chaetomium*.—J. M. GREENMAN.

Revision of Eucalyptus.—The recent issue of Volume II, part 2, continues MR. MAIDEN'S[5] excellent revision of this genus. The present part contains descriptive matter relating to ten species and four full-page illustrations. This work can be used advantageously in conjunction with the "Forest flora of New South Wales" by the same author.—J. M. GREENMAN.

NOTES FOR STUDENTS

Cystidia of Coprinus.—BULLER[6] has given an interesting account of his studies on the cystidia of *Coprinus atramentarius*. The lamellae of this species are very thin, broad, with parallel sides, and lie very close together. Because of their soft texture and extreme flexibility, many of them would lie very close together, or actually adhere, were it not for some kind of stay or prop for spacing them. The spores, then, which are shot off from the sterigmata could not fall down and out from the interlamellar spaces. The cystidia function as props to hold the lamellae equidistant. They are large cylindrical cells, with a slender stalk, which grow out from the subhymenium, the broad portion extending across the interlamellar space against the opposite gill surface or sometimes slightly entering it. They are 120–170×20–30 μ, quite evenly distributed, there being about 75–100 on each square mm. of gill surface.

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[4] North American flora, Vol. III, part 1, pp. 1–88. New York Botanical Garden. December 29, 1910.

[5] MAIDEN, J. H., A critical revision of the genus *Eucalyptus*, Vol. II, part 2, pp. 61–100, *pls. 53–56*. Sydney: William Applegate Gullick. 1910.

[6] BULLER, A. H. R., The function and fate of the cystidia of *Coprinus atramentarius*, together with some general remarks on *Coprinus* fruit bodies. Annals of Botany 24:613–629. *pls. 50, 51*. 1910.

The large number of cystidia thus crossing the interlamellar spaces would themselves be a great hindrance to the escape of the spores in their fall were it not for the fact that they disappear from the area of spore discharge just prior to the maturity and discharge of the spores. The author has shown in a previous publication[7] that in a large number of Hymenomycetes studied the spores are shot from the sterigmata to near the middle of the interlamellar space, and then fall slowly downward and out where they are caught by air currents. He also has shown that in large Coprini like *C. comatus*, where the gills are broad and lie very near each other, the maturity and discharge of the spores begins over a limited area at the lower end and edge of the gills and proceeds upward, and that this is followed by the deliquescence of the lamellae in the same succession, thus leaving a broader space for the fall of the spores. He believes this deliquescence is brought about by enzymes formed in the cells, and so applies the term "auto-digestion."

He now shows that in *C. atramentarius* the same progress of spore development, discharge, and autodigestion of the lamellae takes place, and further, that the cystidia disappear in advance of spore discharge by a similar autodigestion, the fluid content of the large cystidium perhaps being absorbed by the subhymenium, while the wall is digested. In *C. comatus* he says there are no cystidia on the sides of the gills, but the edges are provided with numerous larger, elongated cells which are crowded and many of which extend laterally, thus meeting those of adjacent gills. This broad gill margin, which is absent in *C. atramentarius*, thus serves to prop the gills apart.

In his general remarks on *Coprinus* fruit bodies, he points out that the type of gill in *Coprinus*, very thin and with parallel sides, is not so well adapted to spore escape as the thicker and more or less V-shaped gill of the mushroom (*Agaricus campestris*) type, since the overhang permits the spores to escape readily, and thus they are maturing simultaneously over the entire hymenial surface. The lamellae of the Coprini which lack this overhang mature their spores from below upward. Autodigestion removes the older portions after spore discharge and the cystidia before spore discharge, the whole series of events showing a remarkable adaptation.

He has now determined that even in the plicate Coprini there is slight autodigestion of the lower edge of the gills. The splitting of the gill from above downward probably gives an overhang here, and thus the form of the gill is ultimately more of the V-shape.

He has found cystidia as props in *C. atramentarius*, *C. narcoticus*, *C. stercorarius*, *C. fimetarius*, and *C. niveus;* while the following lack cystidia on the sides of gills but have the tumid margin: *C. comatus*, *C. sterquilinus*, and *C. plicatiloides*. Autodigestion has been observed in eight species of *Coprinus*.

In his general remarks on cystidia he states that they are unbranched. However, one genus of Thelephoraceae (*Asterostroma*) and one of Hydnaceae

[7] BULLER, A. H. R., Researches on Fungi. pp. 287. 1909.

(*Asterodon*) are so named because of the presence of stellately branched cystidia. In *Mycena lasiosperma* Bres.,[8] the ends of the cystidia are several times branched. The ends of the cystidia in several species of *Pluteus*[9] are branched into a group of verticillate prongs. Their presence, absence, or variability in certain genera is as often accounted for by the action of the systematist as by any natural relationship of the forms.—GEO. F. ATKINSON.

Salt marsh development.—The theories advanced for the origin and development of salt marshes, with their typical plant associations, have postulated a shore being built up in bays, estuaries, and barrier-protected lagoons by organic matter resulting from the marsh vegetation and its entangled silt, resulting in a progressive plant succession. Recently DAVIS[10] studied numerous sections of salt marshes in the vicinity of Boston, and found that the deposits were largely composed of the remains of salt marsh plants growing only within a vertical range of about three feet from high tide; and still more remarkable, thick beds of peat formed almost entirely from turf built by *Spartina patens*, a salt marsh grass with even more restricted vertical range. In other instances fresh water deposits were found below the salt marsh peat. Similar but much more limited data previously presented by PENHALLOW, as a result of investigations on the Maine coast, in an article reviewed in this journal,[11] caused him to assign to the phenomena the same explanation as that now given by DAVIS, namely, that the coast has for centuries been gradually subsiding. Peat deposits sixteen feet in thickness indicate this as the minimum amount of subsidence in the Boston area. This region, therefore, would present an interesting example of a static plant formation as a response to an actively dynamic topography, the rate of upbuilding by the vegetation being the same as that of the coastal subsidence. That subsidence was not constantly maintained throughout the entire period of time required for the formation of the deposits under investigation is shown by the presence of at least one bed of fresh water peat including tree stumps between two layers of *Spartina patens* turf.

Further evidence of a similar character is furnished by BARTLETT[12] from a study of a marsh at Woods Hole (Mass.), where similar peat deposits were found with large stumps of *Chamaecyparis thyoides* upon the beach where they were submerged at high tide and yet under conditions where there could have been no lowering due to undermining. Sections of this marsh also showed fresh water deposits sixteen feet below the present high tide level. Such data

[8] Fung. Trid. **1**:33. *pl. 37. fig. 1.* 1883.

[9] For example, see *Pluteus cervinus* in PATOUILLARD, N., Tab. Analyt. Fung. **1**:152. *pl. 335.* 1885.

[10] DAVIS, CHARLES A., Salt marsh formation near Boston and its geological significance. Economic Geology **5**:623–639. 1910.

[11] BOT. GAZETTE **45**:352. 1908.

[12] BARTLETT, HARLEY H., The submarine *Chamaecyparis* bog at Woods Hole, Mass. Rhodora **11**:221–235. 1909.

necessitate a modification of the current theories for the development of salt marshes, and lead DAVIS to conclude that "salt marshes in the area under consideration are features of and an accompaniment to coastal subsidence." The rate of subsidence is variously estimated by these and other investigators at from rather less than one foot per century to double that amount.

BARTLETT shows that a close relation exists between the chlorine content of the soil water and the limits of the various plant associations in the salt marsh. Similar data are given by HARSHBERGER[13] for some of the salt marshes of New Jersey. These are mostly formed behind barrier beaches and are of relatively small area. Probably the most valuable portions of this paper are careful plant lists and the plotting of the vegetation of various typical areas, which will permit further investigators to trace with exactness the development and succession of the various plant associations. It also affords records of the natural vegetation in a region where man is making such changes in the surface and drainage that the original plant associations are rapidly disappearing. Similar records are also given for certain fresh water ponds and swamps formed by the advance of sand dunes across the outlet of various streams.—GEO. D. FULLER.

Biological life forms.—RAUNKIAER'S application of his biological life forms to phytogeography has been translated into German by Miss TOBLER,[14] so that his interesting results are now available to a wider circle of readers. His classification of plants into thirty biological types, based primarily upon the method by which the plant passes the unfavorable season of the year, has already been discussed in this journal.[15] These have now been reduced to ten somewhat broader groups: stem succulents, epiphytes, megaphanerophytes and mesophanerophytes, microphanerophytes, nanophanerophytes, chamaephytes, hemicryptophytes, geophytes, helophytes and hydrophytes, and therophytes or annuals. The flora of a region is then classified into these ten groups, and the number of species in each group expressed in per cent of the total. This numerical arrangement is called a biological spectrum. By arranging these spectra for different regions in order, there is given an easy method of comparing the life forms of vegetation, not only with each other, but also with the flora of the world as a whole. From these spectra it is seen that the tropics are characterized by an excess of the various classes of phanerophytes, deserts by chamaephytes and therophytes, the temperate zone by hemicryptophytes, and the arctics by hemicryptophytes and chamaephytes. For the more northern floras the author finds that the number of chamaephytes

[13] HARSHBERGER, JOHN W., The vegetation of the salt marshes and of the salt and fresh water ponds of northern coastal New Jersey. Proc. Acad. Nat. Sci. Philadelphia **61**:373–400. 1909.

[14] RAUNKIAER, C., Statistik der Lebensformen als Grundlage für die biologische Pflanzengeographie. Beih. Bot. Centralbl. **27**²:171–206. 1910.

[15] BOT. GAZETTE **44**:392. 1907.

is especially significant. From an exhaustive study of local floras he has drawn circumpolar biochores, connecting regions with similar proportions of chamaephytes. The biochores of 10 per cent, 20 per cent, and 30 per cent are chosen to separate four floral zones, which he distinguishes as follows: a cold temperate or hemicryptophyte zone, south of the 10 per cent biochore; a boreal zone, between the 10 per cent and 20 per cent biochores; an arctic zone, between the 20 per cent and 30 per cent biochores; and an arctic-nival zone beyond the 30 per cent line. The same methods are also applied to alpine floras, and the number of chamaephytes is found to increase in the same way with the altitude. RAUNKIAER'S chief object is apparently the recognition of certain types of climate, the results of which are expressed in the vegetation. His methods will probably have a much greater value in characterizing floral regions, irrespective of their climate, and will have the great advantage of basing the distinctions between regions upon the plants themselves, rather than upon any physical feature of the environment. It remains to be seen whether his chief biochores, chosen at certain round numbers and from one life form only, will eventually prove to be the most important.—H. A. GLEASON.

Gas movement.—OHNO[16] has uncovered a most interesting situation in the rapid gaseous output from the leaf of *Nelumbo nucifera*. It is borne some distance above the water, and in the central region over the petiole there is a considerable depression. If on a warm sunny day one places some water in this depression, he will see a rapid extrusion of gas, which amounts to several times the volume of the leaf in a relatively short period. Analysis shows that the gas contains the percentage of O_2 found in air. A like volume is given off by a detached leaf with its petiole in water, even in darkness if the upper surface is warmed. All these facts show that it is not O_2 produced by photosynthesis, and indicate that it is air. Any condition that keeps the air over the leaf dry, sets up such an extrusion of gas. The phenomenon is best explained by the behavior of a model made by OHNO, which he states is a modification of forms before used, to show, in other connections, the physical principle which he believes is applicable here.

A porous clay cup is filled with moist sphagnum and the open end supplied with a one-holed rubber stopper and glass and rubber tubing. The end of the latter dips just a little under the water. The porous cup is heated gently on a warming stage. The air begins streaming out of the tube and continues until it amounts to several times the volume of the porous cup. It ceases only when the water supply of the sphagnum is exhausted. The air on the outside of the tube is relatively dry and the gas pressure there is mainly air. Inside there is a considerable water vapor pressure which decreases the air density. For this reason there is an inward diffusion of air, and, according to the Graham law, an even more rapid outward diffusion of water vapor. The lost water vapor is constantly resupplied by the moist sphagnum. There results an

[16] OHNO, N., Ueber lebhafte Gasausscheidung aus den Blättern von *Nelumbo nucifera* Gaertn. Zeitschr. Bot. **2**:641–664. 1910.

increased internal pressure of gas which causes the streaming from the tube. This continues until the sphagnum is dry.

OHNO conceived that the leaf of *Nelumbo* acts in a similar way, taking in the air thus by diffusion, which increases the internal pressure and leads to an extrusion at the central region where the texture is loose. He examined a number of other plants, but found no other case of a similar exchange.—WILLIAM CROCKER.

Respiratory intensity.—ROSÉ[17] finds that the respiratory intensities of leaves, measured by cc. of CO_2 given off per hour per gram of green weight, varies with the illumination under which the plant is grown, and also with the stage of development of the plant. *Pisum sativum* and *Teucrium Scorodonia* were grown under cloth screens of various thicknesses. The light stopped by the screens was measured by means of a Vidal photometer. ROSÉ used four light intensities: V is full sunlight, IV is $V-2x$, III is $V-16x$, II is $V-22x$, x being the amount of light absorbed by a 5 mm. glass plate. Leaves were taken from the plants at different stages of their development, inclosed in a chamber with a known quantity of air, and put in a dark room. After a time the gas in the chamber was analyzed. For *Pisum sativum*, when two leaves have developed, the maximum respiratory intensity was found to be at illumination V, and there is a gradual decrease to II; but in the later stages the maximum is either at III, with a secondary increase at V, or the reverse. ROSÉ found that the structure of leaves developed under III and II was greatly modified. There was less lignified tissue and less cellulose; therefore, he thinks, there must be a greater amount of protoplasm and of carbohydrates in a given weight of leaf. There is less water in III than in II, therefore a greater percentage of oxidizable substance per gram of green weight. So, the author says, the respiratory maximum is displaced from V, the place of greatest dry weight, to III, the place of greatest amount of oxidizable substances. *Teucrium Scorodonia*, on the other hand, being a shade plant, has its greatest respiratory energy at IV, with its greatest dry weight.

The author's explanations of his results are not convincing. Some quantitative determinations of the enzymes present would be of value. The results found for leaves under the different illuminations would have been more nearly comparable if the water variant had been eliminated by measuring the respiration for a unit of dry weight.—SOPHIA ECKERSON.

Sporogenous tissue of Piper Betel.—The work of JOHNSON among Piperaceae is well known to morphologists, and he has now extended it by including *P. Betel monoicum*,[18] a climbing Jamaican species with monosporangiate

[17] ROSÉ, EDMOND, Énergie respiratoire chez les plantes cultivées à divers éclairements. Rev. Gén. Botanique **22**:385–398. 1910.

[18] JOHNSON, DUNCAN S., Studies in the development of the Piperaceae. I. The suppression and extension of sporogenous tissue in the flower of *Piper Betel* L. var. *monoicum* C. DC. Jour. Exp. Zool. **9**:715–749. *figs.* 71 (year of publication not cited in separate).

flowers and immersed ovaries. The form is interesting in being dioecious, monoecious, or "monoeciously polygamous." The development of the sporangiate structures is of the usual angiospermous type. It is noteworthy that 100 or more antipodals appear and persist in the seed, although they contain little reserve food, which occurs chiefly in the starchy perisperm.

Chief attention, however, is given to the extreme variability in the development of sporogenous tissue as shown by different spikes or by different flowers of the same spike. The number of microsporangia produced by a stamen may vary from none to four, and the extent of a sporangium is widely variable. The point is made that these differences are not determined during the course of development, but are constant from the time of the initiation of the sporogenous tissue. Space relations in the spike hold no relation to the differences, for any condition may develop at any region of the spike. All that the author can suggest is that "the real cause is probably to be sought in those factors, internal or external, that disturb the normal production or course of movement of material in the plant."

Incidentally, the author concludes "that the tissue of the young spike, and often of the individual flower, must be hermaphrodite in character," since the differentiation of the two kinds of sporogenous tissue, involving the subsequent development of the two kinds of sexual tissue, "must take place at or after the initiation of the rudiments of the parts of the flower."—J. M. C.

Philippine forests.—WHITFORD'S continued investigations in the Philippine forests are making us better acquainted with tropical vegetation in comparison with the more familiar vegetation of the United States and Europe. A recent paper gives a detailed account of the forests dominated by members of the Dipterocarpaceae, a family whose name has to most of us an unfamiliar sound, though in the Philippines it is even more important than are pines and oaks with us, since it makes up 75 per cent of the virgin forest area;[19] of the 40,000 square miles of Philippine virgin forest, 30,000 square miles are dominated by dipterocarps. From the lumberman's point of view the dipterocarps may be divided into three categories: those which yield hard and durable timber; those which yield a timber comparable to that of our hard pines; and those whose timber qualities resemble those of our soft pines. Dipterocarp timber compares favorably as to commercial value with the more familiar timbers of Europe and the United States. While some forests of temperate regions surpass those of the Philippines in the matter of bulk, the latter perhaps equal any temperate forests when the amount of the annual increment is taken into account together with the bulk. The best forests are found where climatic, edaphic, and biotic factors are at their optimum. Obvious growth rings occur in some trees, but are lacking or obscure in others; as yet it is not

[19] WHITFORD, H. N., Studies in the vegetation of the Philippines. I. The composition and volume of the dipterocarp forests of the Philippines. Phil. Jour. Sci. 4:699–725. *pls.* 7. 1909.

known whether the growth rings where found are annual or seasonal, but from the data now in hand it appears that the soft wood trees become mature in the Philippine tropical forest in one-half to two-thirds the time that is taken by similar trees in the climate of the northern United States.—H. C. COWLES.

A non-corticated Chara.—Material of such a form was studied by Miss SLUITER,[20] along with *C. contraria* and *C. dissoluta*. The non-corticated form appeared in a laboratory culture of *Nitella* which had died down, and was also found later during an excursion to the upper Zürich Sea in the region of Busskirch. The two problems the author set herself for solution are: (1) What are the relations between *Chara dissoluta* and *C. contraria?* (2) Does the constantly non-corticated form of Busskirch belong in the *C. contraria* group? Is it to be joined with *C. dissoluta*, or are the relations to other non-corticated forms closer?

The main work is divided into three parts: the development of the shoot and its side-organs in *C. contraria;* that in *C. dissoluta;* and that in the *Chara* from Busskirch. Each part is subdivided into the internal and external features. In the results and conclusions the author states that there is great agreement between *C. contraria* and *C. dissoluta* f. *helvetica*. She believes there is not sufficient evidence to consider the latter as one of the many forms of the former, and would not, from her investigation, place it next to *C. contraria*. As to the non-corticated *Chara* of Busskirch, the non-corticated forms of *C. coronata* and *C. stelligera*, which have appeared before in Europe, show no relation to it. Other non-corticated species are no more similar. The author decides that the form must fall in with *C. dissoluta* f. *helvetica* and *C. contraria*. She believes that it must be designated as *C. dissoluta* f. *helvetica*, and that the entirely non-corticated form can appear independently from a one-layered corticated form.—NORMA E. PFEIFFER.

Synapsis.—In a short but important paper, LAWSON[21] presents an interpretation of synapsis entirely at variance with current views, and supports his interpretation with such convincing evidence that some of our current notions must be revised. The name synapsis implies that it is a contraction stage, and as such it has been regarded. LAWSON shows conclusively that there is no contraction of the chromatin mass during the phase known as synapsis. For illustration he has taken the pollen mother cells of *Smilacina*, because it is easy to get complete series of stages in a single section, but he has confirmed the results secured in this genus by a study of algae, fungi, bryophytes, pteridophytes, gymnosperms, and other angiosperms.

During the growth of the spore mother cell, the great accumulation of nuclear sap causes the nuclear cavity to expand until it reaches two or three

[20] SLUITER, CATH[a]. P., Beiträge zur Kenntnis von *Chara contraria* A. Braun und *Chara dissoluta* A. Braun. Bot. Zeit. **68**: 125–168. *pls. 4–8. figs. 21.* 1910.

[21] LAWSON, A. ANSTRUTHER, The phase of the nucleus known as synapsis. Trans. Roy. Soc. Edinburgh **47**: 591–604. *pls. 1, 2.* 1911.

times its original size, the chromatin remaining in one place, while the rest of the nuclear cavity is occupied only by the sap. A complete series of measurements shows that the chromatin area has not diminished. Although there is no contraction, important changes take place in the chromatin during synapsis. There is some evidence that the reticulum of the resting nucleus is composed of a number of threads, and that this number corresponds to the diploid number of chromosomes. Further, the threads are double and there is no evidence of any blending or fusion, the actual reduction occurring much later than the period known as synapsis. A paper dealing with the details of reduction is to follow.—CHARLES J. CHAMBERLAIN.

Turgescence and respiration.—MAIGE and NICOLAS[22] have performed some very interesting experiments upon the effect of turgescence upon respiration. The materials used were various buds, leaves, and embryos. The gas determinations were made by the Bonnier-Mangin method. The work is reported under three heads: effect of increase of turgescence, effect of decrease of turgescence, and effect of a decrease followed by an increase. A rise in turgescence is always followed by increased production of CO_2, intake of O_2, and an increase in the ratio CO_2/O_2. A fall in turgescence produces similar but less marked effects in material taken directly from the plant or soaked for a period in 5 per cent sucrose. In material previously soaked in 10 or 20 per cent glucose, this treatment always gives a decrease in CO_2, O_2, and frequently in the CO_2/O_2. Each change, in the decrease followed by the increase, generally gave an increase in CO_2, O_2, and CO_2/O_2. These facts are new and most interesting, but the interpretations will not find universal acceptance. The authors believe that increased turgescence increases respiration by increasing growth; and decreased turgescence by concentrating the oxidizable solutes of the cell. The first stimulative effect they consider the greater. The authors postulate an optimum concentration for the oxidizable solutes of the cell, and attribute the reversal of behavior after treatment with the strong glucose solutions to this optimum being passed.—WILLIAM CROCKER.

New mesozoic plants.—JEFFREY[23] has described a new araucarian genus (*Woodworthia arizonica*) from a triassic forest of Arizona. The wood is of the *Araucarioxylon* type, but the short shoots are abietineous, and persisted in the wood of the trunk throughout the life of the tree. It is suggested that short shoots characterized the older coniferous stock, and that this would fit into the current explanation of the coniferous ovuliferous scale as a modified short shoot. The leaf traces did not persist in the secondary wood, as they do among the living araucarians, but JEFFREY does not regard persistent leaf traces as an ancestral character of the coniferous stock, as SEWARD and LIGNIER have claimed, but as a more recently acquired character. The testimony of *Wood-*

[22] MAIGE, A., et NICOLAS, G., Recherches sur l'influence des variations de la turgescence sur la respiration de la cellule. Rev. Gén. Botanique **22**:409–422. 1910.

[23] JEFFREY, E. C., A new araucarian genus from the Triassic. Proc. Boston Soc. Nat. Hist. **34**:325–332. *pls. 31, 32.* 1910.

worthia is thought to strengthen the evidence of the approximation of Araucarineae and Abietineae in the early Mesozoic, and of the more primitive character of the latter.

The same investigator[24] has also published a new species of *Prepinus* from the Cretaceous of Martha's Vineyard, which differs from the type species of Staten Island in that the wood of the short shoots has numerous resin canals in two or more rows, and the pith is without sclerotic nests. The conclusion is reached that "ligneous resin canals" are features of the oldest Abietineae, as shown now by the structure of the archaic genus *Prepinus* and also by that of the oldest species of *Pityoxylon*.—J. M. C.

Chlorophyll and photosynthesis.—IRVING,[25] working in BLACKMAN'S laboratory, has studied the relation between the early development of chlorophyll and of the photosynethetic power. He finds that seedlings developing in darkness and later transferred to light, or developing from the first in light, are able to fix all CO_2 produced by respiration only after becoming almost fully green. When considerable photosynthetic power does appear, it develops rapidly. The author believes the photosynthetic activity up to this stage never fixes more than 10 per cent of the CO_2 produced by respiration, and never amounts to over 1 per cent of the activity after the full development of the chlorophyll. The following quotation from the summary shows the significance of the work: "We are forced to conclude that the first development of this function is not in any relation to the amount of chlorophyll produced, and that the amount of chlorophyll present is never a limiting factor to assimilation in these early stages of the assimilating organs. If this is so, then it must be some other component part of the photosynthetic machinery which controls the beginning of complete functional activity. This part is not developed by illumination so quickly as the green pigment is developed, and therefore the pigment, and other parts of the total machinery, lie idle at the stage we have examined, awaiting the developing of the last factor."—WILLIAM CROCKER.

Reduction divisions of Oenothera.—DAVIS[26] has published another confirmation of the earlier work of GATES[27] and of GEERTS[28] on reduction in

[24] JEFFREY, E. C., A new *Prepinus* from Martha's Vineyard. Proc. Boston Soc. Nat. Hist. **34**:333–338. *pl. 33.* 1910.

[25] IRVING, A. A., The beginning of photosynthesis and the development of chlorophyll. Annals of Botany **24**:805–818. 1910.

[26] DAVIS, B. M., The reduction divisions of *Oenothera biennis*. Annals of Botany **24**:631–651. *pls. 52, 53.* 1910.

[27] GATES, R. R., Pollen development in hybrids of *Oenothera lata*×*O. Lamarckiana*, and its relation to mutation. BOT. GAZETTE **43**:81–115. *pls. 2–4.* 1907.

———, A study of reduction in *Oenothera rubrinervis*. BOT. GAZETTE **46**:1–34. *pls. 1–3.* 1908.

———, The behavior of the chromosomes in *Oenothera lata*×*O. gigas*. BOT. GAZETTE **48**:179–199. *pls. 12–14.* 1909.

[28] GEERTS, J. M., Beiträge zur Kenntnis der Cytologie und der partiellen Sterilität von *Oenothera Lamarckiana*. Recueil Trav. Bot. Néerl. **5**:93–208. 1909.

Oenothera. He gives the telosynaptic account, involving the segmentation of the thick spirem (pachynema) into a single chain of chromosomes. No new facts regarding reduction are brought out, and there are no deviations from the history of reduction as already known for *O. Lamarckiana* and its mutants. The reviewer, in a paper before the Botanical Society of America in 1908,[29] showed that the process of reduction in the mutating forms can be duplicated by figures of every stage in *O. biennis* and *O. laevifolia*, there being the same tendency not to form close pairs, and the same loose arrangement of the chromosomes on the heterotypic spindle. This permits of occasional irregularities in the distribution of the chromosomes during reduction, and these were found to occur in normal material of *O. biennis*, as in the mutating forms. Thus no differences in the method of reduction in the different species and races of *Oenothera* have yet been found, except in *O. grandiflora*, in which DAVIS[30] obtains what he thinks are rings, in the place of loose heterotypic bivalents. As the reviewer has already pointed out,[31] the supposed rings are probably due to a greater attraction between homologous chromosomes in *O. grandiflora* than in the other forms.—R. R. GATES.

Florida peat deposits.—This report[32] is the result of a general survey of peat formations and distribution in Florida, without detailed examination or studies. Immature topography affords the most favorable surface water conditions for deposit of peat if associated with proper climate, not too dry nor too cold, as in glaciated areas of eastern North America and of Europe, and in the Coastal Plain of the southeastern United States. Florida seems to offer ideal conditions, having a greater variety of swamps, bogs, marshes, and places where peat accumulates than any equal area in North America, and also an ample rainfall. A tentative classification of the peat is based on the nature of the water with which it was found associated: salty, muddy, calcareous, swamp waters, with several exceptional deposits. The best and deepest peat is that in the peat prairies classed as "filled lakes"; under the same division is included the northern everglades. Analyses of 53 samples indicate a good average quality, the fuel value being above the average for pressed peat (8500 B.T.U.; DAVIS) for two-thirds of the samples. The list of peat plants includes 83 families of angiosperms, 6 conifers, *Isoetes*, 2 lycopodiums, *Azolla* sp., 11 ferns, several mosses, and *Chara*.—LAURA GANO.

Sporangia of Weichselia.—This is a cretaceous genus of fernlike plants known heretofore only from the bipinnate sterile fronds. The question has

[29] GATES, R. R., Further studies of oenotheran cytology. Science N.S. **29**: 269. 1909.

[30] DAVIS, B. M., Pollen development of *Oenothera grandiflora*. Annals of Botany **23**: 551–571. *pls. 41, 42*. 1909.

[31] BOT. GAZETTE **49**: 64–66. 1910.

[32] HARPER, ROLAND M., Preliminary report on the peat deposits of Florida. Included in third Ann. Rep. Fla. State Geol. Survey. 1910.

been raised whether it is not a belated member of the Cycadofilicales, and therefore any further information concerning it is desirable. BOMMER[33] has obtained material that supplies additional information, which he publishes in a preliminary announcement. The vascular structure of the plant suggests to him possible relationship with the Matoniaceae, but the sporangia, now found attached, are of special interest. They occur in synangia which resemble inverted cones, and possess an incomplete annulus, as in *Matonia*. Each synangium includes 10–15 sporangia, and the synangia themselves are grouped so as to form spherical bodies 3–4 mm. in diameter. These synangial groups are borne thickly on apparently naked branches of the frond. Such fructifications have been found heretofore detached. BOMMER is evidently undecided whether the most obvious testimony at present should decide for *Matonia* affinities; or whether certain vague suggestions should decide for a *Marattia* connection; or whether, after all, these synangia may not be the microsporangia of Cycadofilicales. This lack of decision is commendable.—J. M. C.

A classification of plants.—Professor BESSEY has long been interested in a general classification of plants which is quite a departure, in many respects, from current schemes. In 1909 he published in outline his ripened conclusions, together with the principles involved, and now he has furnished a key[34] by which the groupings are defined, so far as a key can define. It is impossible to give an account of the views expressed without reprinting the paper, for it is in itself the shortest possible statement. It is sufficient to say that the 4 conventional main groups are dissipated into 14 "phyla," whose technical and common names may serve to indicate them: Myxophyceae (slime algae), Protophyceae (simple algae), Zygophyceae (conjugate algae), Siphonophyceae (tube algae), Phaeophyceae (brown algae), Carpophyceae (higher algae), Carpomyceteae (higher fungi), Bryophyta (mossworts), Pteridophyta (ferns), Calamophyta (calamites), Lepidophyta (lycopods), Cycadophyta (cycads), Strobilophyta (conifers), Anthophyta (flowering plants). These phyla are broken up into 32 classes and 94 orders, not including the dicotyledons, which constitute class 33, with 5 "super-orders," the list of orders not being given.—J. M. C.

Seeds of the Conostoma group.—OLIVER and SALISBURY[35] have assembled the material of *Conostoma* for investigation, and have compared it with *Lagenostoma*, *Physostoma*, and *Gnetopsis*. A full description is given of *C. oblongum* and *C. anglo-germanicum*, and this is followed by a comparison with related

[33] BOMMER, CH., Contribution à l'étude du genre *Weichselia*. Note préliminaire. Bull. Soc. Roy. Bot. Belgique **47**: 296–304. *figs. 18*. 1911.

[34] BESSEY, CHARLES E., The phyla, classes, and orders of plants. Trans. Amer. Micr. Soc. **29**: 85–96. 1910.

[35] OLIVER, F. W., and SALISBURY, E. J., On the structure and affinities of the paleozoic seeds of the *Conostoma* group. Annals of Botany **25**: 1–50. *pls. 1–3. figs. 13*. 1911.

types and a taxonomic presentation of the group, in which *Gnetopsis elliptica* is placed provisionally with *Conostomum* in the "Conostomeae." A brief discussion of the "pollination mechanisms" of the Lagenostomales calls attention to the three distinct types exhibited by the group: that in which the free but approximated lobes of the integument surrounded and overtopped the pollen chamber and probably at pollination formed a funnel (*Physostoma*); that in which a massive "canopy" was pierced by a long micropyle (*Conostoma*); and that in which the compact canopy closely invested the conical pollen chamber, whose orifice reached to the outer surface (*Lagenostoma*). A glossary is provided at the close of the paper, since such terms as the "blow-off layer," "lagenostome," and "plinth" are not easily separated from the well-worn terms heretofore applied to the same structures.—J. M. C.

Anatomy of Azolla.—QUEVA[36] has investigated the vascular anatomy of *Azolla filiculoides*, and has secured some interesting facts. The vascular elements are differentiated in the floating, dorsiventral stem, those of the dorsal region being tracheids of small caliber, and those of the ventral region being vessels of large caliber. The transverse section of the xylem is circular, the circle being incomplete alternately on the right and left sides in the dorsal region; so that the section is really an arc which is open alternately right and left, corresponding to the alternating leaf traces. The heavy vessels of the ventral region are connected exclusively with the roots. The interpretation suggested is that the dorsal group of vessels represents a reduced bipolar group, connected at the poles with leaf traces; and that the ventral group is merely an "apolar" mass related to the roots. The amount of vascular tissue retained would seem to be a remarkable feature in a stem with such an extremely hydrophytic habit.—J. M. C.

Germination of Helianthus.—MILLER[37] has studied the transformations of the reserve materials of the sunflower during germination. The work shows both chemical and biological excellence. Main emphasis is put upon the transformation of fats. The fats extracted from the cotyledons show low acid values at all times, while those from the hypocotyl very early, and continuously thereafter, show high acid values. It was not determined whether the fats are translocated as such or as hydrolyzed products. The iodine value of the fats falls as germination advances, due as the author believes to the absorption of oxygen. As germination progresses, the fats decrease rather rapidly, while the carbohydrates increase. This furnishes further evidence for the established view that during germination fats are transformed to carbohydrates.—WILLIAM CROCKER.

[36] QUEVA, C., L'*Azolla filiculoides* Lam., étude anatomique. Mém. Soc. Hist. Nat. Autun **23**: pp. 24. *figs. 22.* 1910.

[37] MILLER, EDWIN C., A physiological study of the germination of *Helianthus annuus*. Annals of Botany **24**:693–726. 1910.

Geotropism of hypocotyls and cotyledons.—SCHÜTZE,[38] working in PFEFFER's laboratory, has published a paper on the geotropic behavior of hypocotyls and cotyledons. The work adds some facts to that of COPELAND[39] on this subject. For hypocotyls, *Phaseolus multiflorus*, *P. vulgaris*, *Helianthus annuus*, *Cucurbita Pepo*, *Ricinus communis*, *Vicia Faba*, and others were used; and for cotyledons, *Phoenix dactylifera* and *Yucca angustifolia*. Both the cotyledons and hypocotyls showed positive geotropic reaction after the removal of the root tips. Traumatropic response followed a one-sided injury of the root tip. The change from positive to negative geotropism always begins at the base of the hypocotyl and travels upward. The zone of most rapid growth always accompanies this zone of change.—WILLIAM CROCKER.

Ovule of Bruniaceae.—This is a family of 12 genera, endemic in South Africa, and one of the group of families that forms a penumbra about the Saxifragaceae. So isolated does it seem, that SAXTON[40] has investigated the structure of the ovule and embryo sac. He finds a single massive integument, and in *Brunia* an embryo sac completely replacing the nucellus and packed with starch, which almost completely disappears before fertilization; in *Berzelia* and *Staavia* a little of the basal nucellar tissue persists. The solitary megaspore mother cell and the tetrad present nothing unusual; and, so far as the ovular structures are concerned, there is nothing suggestive of relationship. Certainly there is no suggestion of an "ancient type," especially since a single massive integument is a feature of the Sympetalae.—J. M. C.

Evaporation in Jamaica.—Observations made by BROWN[41] on the grounds of the Cinchona Laboratory of the New York Botanical Garden in the Blue Mountains of Jamaica, extending over a period of 25 days in May and June 1910, give an unexpectedly low rate of evaporation even in an open grassy clearing (8.2 cc. daily); while in a densely wooded ravine it was less than 1 cc. daily from the standard Livingston atmometer. The use of the non-rain-absorbing atmometer is here reported for the first time, and its results show that, while the general relation of two or more evaporation rates remains the same as for the ordinary atmometer, the numerical factor differs and must approach more nearly to an absolute determination when the non-rain-absorbing instrument is used.—GEO. D. FULLER.

Mistletoe.—YORK[42] has made an anatomical and ecological study of the American mistletoe, confirming several well known facts, such as its dissemi-

[38] SCHÜTZE, RUD., Ueber das geotropische Verhalten des Hypokotyls und des Kotyledons. Jahrb. Wiss. Bot. **48**:377–423. 1910.

[39] BOT. GAZETTE **31**:410–422. 1901.

[40] SAXTON, W. T., The ovule of the Bruniaceae. Trans. Roy. Soc. S. Africa **2**[1]:27–31. *figs. 8.* 1910.

[41] BROWN, WM. H., Evaporation and plant habitats in Jamaica. Plant World **13**:268–272. 1910.

[42] YORK, H. H., The anatomy and some of the biological aspects of the "American mistletoe," *Phoradendron flavescens* (Pursh) Nutt. Bull. Univ. Texas 120. *pls. 13.* 1909.

nation by birds, its water parasitism, its essentially xerophytic structure, and the distortion which it causes in the branches of its host plants. The chief hosts in the vicinity of Austin, Texas, are the hackberry, elm, mesquite, and osage orange. The immunity of certain trees (as the China tree and box elder) appears to be due to the character of the external surface and the thickness of the corky layer.—H. C. COWLES.

Statolith theory.—NĚMEC[43] controverts PEKELHARING'S claim that roots respond to the geotropic stimulus after being freed from statolith starch by growing in 0.025 per cent potassium alum. Aside from potassium alum, NĚMEC used aluminum sulphate and chloride and zinc sulphate as destarching agents. In no case was geotropic response given in absence of statolith starch. With such treatments, marked injury always accompanied absence of starch. He believes that the statolith theory stands in the face of all suggested evidence against it.—WILLIAM CROCKER.

Cytology of Spongospora.[44]—In the current issue of the *Annals of Botany* two investigators present preliminary accounts of their investigations on *Spongospora*, the organism which causes the powdery or corky scab of the potato. Both describe the life history, both note that chromatin at certain stages takes the form of chromidia, and both note resemblances to *Plasmodiophora*, OSBORN suggesting that *Spongospora* should be placed in the Plasmodiophoraceae.—CHARLES J. CHAMBERLAIN.

Light perception.—HABERLANDT[45] answers Wager's arguments against the lens theory of light perception by foliage leaves. In places his answer shows keen retort, though it often lacks any convincing evidence. Such are the methods to which one must resort when one defends a questionable though favorite hypothesis.—WILLIAM CROCKER.

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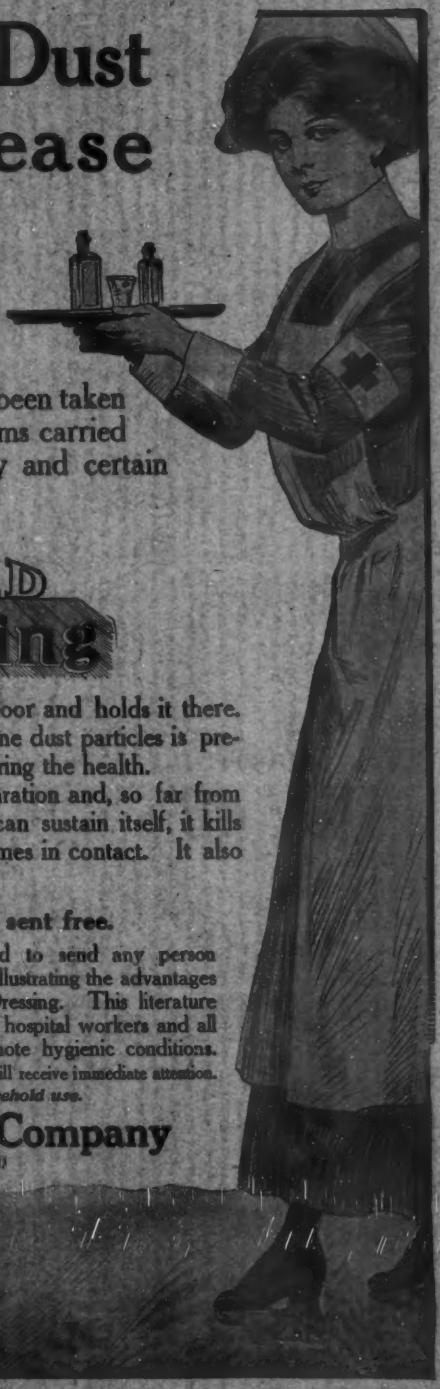
[43] NĚMEC, B., Der Geotropismus entstärkter Wurzeln. Ber. Deutsch. Bot. Gesell. **28**: 107–112. 1910.

[44] OSBORN, T. G. B., A preliminary note on the life history and cytology of *Spongospora subterranea* Wallroth. Annals of Botany **25**: 271. 1911.

HORNE, A. S., Preliminary note on *Spongospora solani* Brunch. Annals of Botany **25**: 272. 1911.

[45] HABERLANDT, G., H. WAGER'S Einwände gegen meine Theorie der Lichtperzeption in den Laubblätter. Jahrb. Wiss. Bot. **48**: 337–390. 1910.

Germ-Laden Dust Spreads Disease



Even with modern systems of ventilation and scrupulous regard for cleanliness, hospitals are exposed to germs.

When all the usual precautions have been taken there still remains the danger from germs carried by dust circulating in the air. An easy and certain way to keep down dust is to use

STANDARD Floor Dressing

It catches the dust as it settles on the floor and holds it there. In this way the germ life which clings to the fine dust particles is prevented from circulating in the air and endangering the health.

Standard Floor Dressing is a special preparation and, so far from containing anything on which bacterial life can sustain itself, it kills most of the disease germs with which it comes in contact. It also gives the floor a cleanly, finished appearance.

Illustrated booklet sent free.

On request we will be pleased to send any person interested, free of charge, a booklet illustrating the advantages of the use of Standard Floor Dressing. This literature should be particularly interesting to hospital workers and all those who are in a position to promote hygienic conditions.

A post card requesting information will receive immediate attention.

Not intended for household use.

Standard Oil Company

(Incorporated)

Baker's Breakfast Cocoa

Registered, U. S. Pat. Off.

Has a most delicious flavor. Is pure and healthful. An ideal food beverage.

GENUINE HAS THIS TRADE MARK ON EVERY PACKAGE

WALTER BAKER & CO. LTD.

ESTABLISHED 1780

DORCHESTER, MASS.

Dust, Dirt and Germs

are best removed from floors by first sweeping with a cloth-covered broom moistened with water containing just a little

Platt's Chlorides,

The Odorless Disinfectant.

A colorless liquid; powerful, safe and economical. Instantly destroys foul odors and disease-breeding matter. Specially prepared for household use. Sold only in quart bottles, by druggists everywhere. An illustrated booklet with valuable sanitary information mailed free. Address Henry B. Platt, 42 Cliff Street, N. Y.

Dusty or damp corners and cracks—nooks behind plumbing and all spots that can't be reached by the scrubbing brush, should be freely sprinkled with a mixture of one (1) part Platt's Chlorides and ten (10) parts of water, by means of a whisk-broom.

THE SOAP
THAT TAKES THE PALM
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have been established over 60 YEARS. By our system of payments every family in moderate circumstances can own a VOSE piano. We take old instruments in exchange and deliver the new piano in your home free of expense. Write for Catalogue D and explanations.

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